



## **A report summarising the existing knowledge basis for assessing the direct cost of provision in the case study areas**

### **D3.1**

Stenger, Anne; Garcia, Serge; Delacote, Philippe; Kere, Eric; Robert, Nicolas; Darses, Ophélie; Gorriz, Elena; Prokofieva, Irina; Varela, Elsa; Vedel, Suzanne Elizabeth; Thorsen, Bo Jellesmark; Ahtikoski, Anssi; Mäntymaa, Erkki; Ovaskainen, Ville; Naskali, Arto; Tyrväinen, Liisa; Bartczak, Anna; Czajkowski, Mikolaj; Giergiczny, Marek; Gatto, Paola; Pettenella, Davide; Secco, Laura; Vidale, Enrico; Wunder, Sven

*Publication date:*  
2011

*Document version*  
Publisher's PDF, also known as Version of record

*Citation for published version (APA):*  
Stenger, A., Garcia, S., Delacote, P., Kere, E., Robert, N., Darses, O., Gorriz, E., Prokofieva, I., Varela, E., Vedel, S. E., Thorsen, B. J., Ahtikoski, A., Mäntymaa, E., Ovaskainen, V., Naskali, A., Tyrväinen, L., Bartczak, A., Czajkowski, M., Giergiczny, M., ... Wunder, S. (2011). *A report summarising the existing knowledge basis for assessing the direct cost of provision in the case study areas: D3.1*.  
<http://dl.dropbox.com/u/58538434/NEWFOREX/Publications/D3.1.pdf>

Project no. 243950

NEWFOREX

New Ways to Value and Market Forest Externalities

Start date of project: 1 December 2009

Duration of project: 4 years

Instrument: CP

Small or medium-scale focused research project

Theme 2: Food, agriculture and fisheries, and biotechnology

FP7-KBBE-2009-3

## **D3.1 A report summarising the existing knowledge basis for assessing the direct cost of provision in the case study areas**

Due date of deliverable: 30 November 2010

Actual submission date: 31 March, 2011

Organisation name of lead contractor for this deliverable: INRA with CSP

Dissemination level: PU



## Authors

### FRANCE

Anne Stenger (INRA LEF)  
Serge Garcia (INRA LEF)  
Philippe Delacote (INRA LEF)  
Eric Kere (INRA LEF)  
Nicolas Robert (INRA LEF)  
Ophélie Darses (INRA LEF)

### SPAIN

Elena Gorriz, CTFC  
Irina Prokofieva, CTFC  
Elsa Varela, European Forest Institute (EFI)-EFIMED, Spain

### DENMARK

Suzanne Elizabeth Vedel, Forest & Landscape, University of Copenhagen (UCPH), Denmark  
Bo Jellesmark Thorsen, Forest & Landscape, University of Copenhagen (UCPH), Denmark

### FINLAND

Anssi Ahtikoski, Finnish Forest Research Institute (METLA), Finland  
Erkki Mäntymaa, Finnish Forest Research Institute (METLA), Finland  
Ville Ovaskainen, Finnish Forest Research Institute (METLA), Finland  
Arto Naskali, Finnish Forest Research Institute (METLA), Finland  
Liisa Tyrväinen, Finnish Forest Research Institute (METLA), Finland

### POLAND

Anna Bartczak, University of Warsaw (UWAR), Poland  
Mikolaj Czajkowski, University of Warsaw (UWAR), Poland  
Marek Giergiczny, University of Warsaw (UWAR), Poland

### ITALY

Paola Gatto, Dept. Land Environment Agriculture and Forestry, University of Padova, Italy  
Davide Pettenella, Dept. Land Environment Agriculture and Forestry, University of Padova, Italy  
Laura Secco, Dept. Land Environment Agriculture and Forestry, University of Padova, Italy  
Enrico Vidale, Dept. Land Environment Agriculture and Forestry, University of Padova, Italy

### BRAZIL

Sven Wunder, Center For International Forestry Research (CIFOR)

## Reference

STENGER A., GARCIA S., DELACOTE P., 2011. A report summarising the existing knowledge basis for assessing the direct cost of provision in the case study areas. Deliverable D3.1 of the research project “NEWFOREX”, Project no. FP7-KBBE 2009-3, European Commission, 38 p.

## Executive summary

This report has as a main objective to identify the cost of provision for forest externalities in each case study and to give some insights for modelling and assessing this cost. This work will target an integrated assessment taking into account that the forest externalities are produced jointly and related to management alternatives. Each case partner contributes to provide key elements for forest externality provision in their respective case area. So a first part is devoted to set up the definitions and concepts necessary to the assessment of cost of provision for forest externalities. The provision of forest externalities in different case studies requires to have some common indicators or measures for each externality and to define the components of the cost of provision. To the direct cost or implementation costs, indirect ones are to be considered like opportunity costs, transaction costs or feedback costs. The second part of the report is focusing on the different methods in relation with the CSPs. Two main approaches are developed, one with technological approaches focusing more on outcomes and objective costs, another one on behavioural approaches. The third part is developing a simple conceptual framework for non industrial forest owners. Cost assessment will require three elements: the reference case or ‘business as usual’ case, the forest management scenarios and the expected impacts and the cost drivers.

## Contents

<b>1. INTRODUCTION.....</b>	<b>7</b>
<b>2. COST OF PROVISION FOR KEY EXTERNALITIES IN FOREST MANAGEMENT .....</b>	<b>8</b>
2.1 The measure of key externalities in forest.....	8
2.1.1 Atlantic urbanised case.....	10
2.1.2 Boreal region case.....	11
2.1.3 The Mediterranean region case.....	11
2.1.4 Mountainous region case .....	12
2.1.5 Central European region.....	14
2.1.6 Developing country case.....	14
2.2 Provision of key externalities in forest: the components of the cost of provision.....	15
2.2.1 Direct costs .....	15
2.2.2 Opportunity costs.....	15
2.2.2.1 Definition of opportunity costs.....	15
2.2.2.2 Estimation of opportunity costs.....	16
2.2.2.3 Data needs .....	17
2.2.3 Transaction costs.....	19
2.2.4 Feedback costs: assessing joint-production characteristics.....	20
<b>3. METHODS FOR ASSESSING COST OF EXTERNALITY PROVISION: A REVIEW .....</b>	<b>21</b>
3.1 Technological approaches .....	21
3.1.1 Bottom up engineering production approach.....	21
3.1.2 Multiproduct cost function .....	22
3.1.3 Contingent market .....	23
3.2 Producer/owner behaviours and preferences .....	23
3.2.1 Industrial private forest owners.....	24
3.2.2 Non-Industrial Private Forest (NIPF) owners.....	24
3.3 Stated and revealed preference approaches .....	26
3.4 Application to the Case Studies.....	26
3.4.1 Biodiversity.....	27
3.4.1.1 Atlantic urbanised case .....	27
3.4.1.2 Boreal region case .....	28
3.4.1.3 The Mediterranean region case.....	30

3.4.1.4	The Mountainous region case .....	31
3.4.1.5	Developing country case .....	32
3.4.2	<i>Recreation</i> .....	34
3.4.2.1	Atlantic urbanised case .....	34
3.4.2.2	Boreal region case .....	35
3.4.2.3	The Mediterranean region case .....	36
3.4.3	<i>Carbon</i> .....	36
3.4.3.1	Atlantic region case .....	36
3.4.3.2	Boreal region case .....	37
3.4.3.3	The Mediterranean region case .....	38
3.4.3.4	Developing country case .....	39
3.4.4	<i>Water and other externalities</i> .....	40
3.4.4.1	Atlantic urbanised case .....	40
3.4.4.2	Boreal region case .....	40
3.4.4.3	Mountainous region case .....	40
3.4.4.4	Developing country case .....	45
3.5	A summarizing table of estimated costs for the provision of forest externalities .....	45
3.5.1	<i>Boreal region case</i> .....	45
3.5.2	<i>Central European region</i> .....	49
<b>4.</b>	<b>A FRAMEWORK FOR ASSESSING COST OF EXTERNALITY PROVISION: SCENARIOS, EXPECTED IMPACTS AND COST DRIVERS.....</b>	<b>50</b>
4.1	Status-quo scenario or ‘Business As Usual’ .....	50
4.1.1	<i>Theoretical framework</i> .....	50
4.1.2	<i>BAU in the CSPs</i> .....	51
4.1.2.1	Atlantic case.....	51
4.1.2.2	Boreal region case .....	52
4.1.2.3	The Mediterranean region case .....	54
4.1.2.4	Mountainous region case .....	54
4.1.2.5	Central european region.....	55
4.1.2.6	Developing country case .....	56
4.2	Forest management scenarios: Key actions and expected impacts on forest externalities .....	57
4.2.1	<i>Theoretical framework</i> .....	57
4.2.2	<i>Key actions and expected impacts in the CSPs</i> .....	58
4.2.2.1	Atlantic urbanised case .....	58
4.2.2.2	Boreal region case .....	59

4.2.2.3	The Mediterranean region case .....	61
4.2.2.4	Mountainous region case .....	63
4.2.2.5	Central European region .....	65
4.2.2.6	Developing country case .....	67
4.3	Cost drivers in providing forest externalities .....	68
4.3.1	<i>Theoretical framework</i> .....	69
4.3.2	<i>Cost drivers in the CSP's</i> .....	69
4.3.2.1	Atlantic urbanised case .....	69
4.3.2.2	Boreal region case .....	70
4.3.2.3	The Mediterranean region case .....	71
4.3.2.4	Central European region .....	71
4.3.2.5	Developing country case .....	72
4.4	Cost assessment .....	72
<b>5.</b>	<b>REFERENCES</b> .....	<b>75</b>
5.1	FRANCE .....	75
5.2	DENMARK .....	79
5.3	ITALY .....	81
5.4	BRAZIL .....	82
5.5	POLAND .....	83
5.6	FINLAND .....	83
5.7	SPAIN .....	86



## 1. INTRODUCTION

Forest externalities can be seen as local public goods (e.g. Lichtenberg et al. 2007), or in some cases as regional, national, or international public goods. Concerning this spatial dimension for (forest) externalities, the reputation effect may play some role, influencing the scale of provision, implying effects on the use side and/or on the supply side. For instance, IUCN Red lists for endangered species are edited for Earth and illustrate the cases for which decisions have to be made, both at the demand side in restricting access to forest and at the supply side in changing forest management practices. While demand for and value of forest externalities are crucial elements to be investigated (see WP2) and are on the increase in many European contexts, complementary investigation is required to assess how changes in forest management impact externality provision and the associated costs to forest owners. In supplying wood according to some management scenarios, forest owners may contribute to either an increase in some forest externalities, and potentially a decrease for other externalities.

WP3 precisely focuses on determining the costs of provision of forest externalities for forest owner's/landowner's. In general, providing a forest externality embodies the idea of assessing both the direct costs of undertaking a specific forest management action, and indirect costs (opportunity costs and feedback costs). This approach will target an integrated assessment taking into account that the externalities are produced jointly and related to management alternatives. Forest management takes place in the context of joint production of wood and externalities. Forest owners themselves may give value to forest externalities they provide. In this context, it is essential to take into account both the monetary dimension of the costs and the perception of these costs to the forest owners. The ownership itself may add a particular private value to what is otherwise externalities, e.g. amenity or biodiversity values of forests. While such private values should be reflected in the prices of forest land, they also alter the objective functions of forest owners, and hence their decisions.

The objective of the task 3.1 is to review existing methods for assessing cost of provision for key forest externalities. We seek to identify in each case study the components of the costs of provision of the externalities, and to give some insights for modelling and assessing these costs.

Each of the case study partners (CSPs) contributes to provide key elements concerning forest externality provision in their respective case area. First, key externalities relevant for each case study have to be identified. Second, a literature review on knowledge and models of previous cost assessment of externality provision has to be provided. Then, basic elements are required to assess the costs of provision: what is the Business-as-usual (BAU) scenario? What are the key forest management actions to be undertaken to

provide the relevant externalities? What are the expected impacts in terms of wood production and externality provision? What are the potential feedbacks among the different externalities? What can be the transboundary effects of externality provision on contiguous forest land and on other land use (e.g., water availability for agriculture)?

The document is organized as follows. A first part is devoted to set up the preliminary definitions and concepts necessary to the assessment of cost of provision of forest externalities. In particular, we deal with the measures of externalities and the different components of costs. In a second part, we review the different methods for assessing costs for externality provision in relation with CSPs. The third part describes a framework for assessing costs of externality from a theoretical model based on household production preferences. This approach is based on a BAU scenario for each CSP followed by the definition of key actions for providing externalities and the description of expected impacts.

## **2. COST OF PROVISION FOR KEY EXTERNALITIES IN FOREST MANAGEMENT**

### ***2.1 The measure of key externalities in forest***

To be able to document the provision of forest externalities to the society, also as a basis for being compensated for costs associated with this provision, requires a shared definition of indicators or measures for each externality both at the supply side and the demand side. These measures allow to capture the effects of forest management scenarios on key externalities and to observe a potential variation in their supply. Because of the nature of our exercise in this project, impacts of alternative management on externalities are in expected terms, taking into account both the characteristics of the case study (technical and human possibilities) and some observed results collected on other identical sites in the past. Technical reasons rely on the biological characteristics of the site like at least the vegetation (composition of the tree species and existing biodiversity) and the climate. Human possibilities are linked to the ownership structure and particularly both to the proportion of private owners and to their fragmentation. In fact, the more they are dispersed, the more it is difficult to get forest externality supply on a contiguous way. These disruptions tend to be a costly limit in the creation of a human network, and they also slow the biological connections. Other reasons can explain the fact that the impacts are uncertain like time horizon and the potential lags between the change in management and the observed results for externality provision. The impacts that can be induced by the different scenarios in forest management are potential and in a long term view. The spatial dimension is important when providing forest externalities, implying changes in management at a large area that is sufficient to observe the modification. This spatial dimension may imply that in case of a large

number of small private properties, a significant number of these forest owners have to participate in a coordinated action across a contiguous area to observe an effect in the provision of externalities.

Common difficulties exist to define measures for externality. They may be due either to the plenty of indicators that can be used; or to the difficulty to find a relevant indicator. Moreover, a majority of these measures are sometimes not directly available because no sufficient observations exist. In the absence of direct measures, some proxies can be used, but they give a global and imprecise idea of externality provision. To measure externality provision, the choice of the most relevant indicator is not an easy task, as it requires to be clear, reliable and credible for the entire society. The choice of the indicators and thus the measures, especially for biodiversity and for recreation, is also spatially constraint. Indeed biodiversity and recreation measures have to be site-relevant, technically observable and clear both for demand and supply adhesion. It means that the spatial scales are very important to know, but they can be different for the supply and the demand sides. The supply side is better identified when providing externalities because it relies on local initiatives and actions developed with forest stakeholders in the case study which are clearly determined. In contrast, the beneficiaries can be in a larger area than the case study at least for biodiversity, carbon storage and recreation. The characteristics of a local supply and a more global demand (than the case study) is true as well for carbon storage but less for water quality or quantity that is more relevant at the catchment's area. These spatial differences are clear when the biodiversity provision for example is in terms of emblematic species implying the regional or national scale and thus having direct impacts on recreational uses too.

Biodiversity provision can be measured according to many criteria but in most of the case, it is in terms of species increase or preservation (i.e. number of endangered species). For water quality or water quantity, a clear measure is more difficult to capture due to the complex relationships between forest management and water despite of some common knowledge. An important issue when studying the link between forest and water concerns the spatial scale at which the question of the impact of forest management on water arises. While water is important for the growth of the trees and conversely the trees are important for water quantity and quality, the question of forest management implies a larger scale than the stand one, and generally it is the catchment area as a whole that must be considered. The presence of forest can thus modify the volume and quality of available water at the catchment area level. So, as he manages his stands, the forest owner must not forget that his management actions also affect the qualitative and quantitative management of water for the society. Broadly speaking, we can say that, compared with an alternative land cover (grassland), the forest has a tendency to reduce the quantity of water available, and to increase its quality (Willis

2002)<sup>1</sup>. Concerning carbon sequestration, it seems easier while measuring the additional amount of carbon due to the forest management change is straightforward.

### 2.1.1 Atlantic urbanised case

At present, the stated preference study for the Atlantic case is expected to deal with recreation, biodiversity and groundwater protection. With regard to recreation the proposed levels of changes to the forest management scenario are the amount of area where accesses outside roads and paths or marked routes in the forest are provided. Biodiversity is expected to be assessed in two ways *i*) based on the level (low, medium, high) of natural dynamics which the management scenario can achieve and *ii*) the number of endangered species which will be preserved. Low natural dynamics are achieved by leaving 5 old trees to decay/hectare, medium level by setting 5% of area with broadleaves aside, and high level by setting 10% of area aside. The producer cost in terms of direct and opportunity costs for this can be assessed based on Jacobsen and Thorsen (2010) and Vedel et al. (2010), where a range of NPV-measures for direct and opportunity costs are given for such management actions across three forest and sites types.

Groundwater protection can be expected to lead to a combination of both improved quality and quantity of groundwater in the future, and in the present study we expect to value this combination in terms of the additional production of clean groundwater (in m<sup>3</sup>). So it is a quantity measure, but in terms of quality we have chosen to connect it with the production of clean groundwater since this is still the status quo scenario for the regions in Denmark with low population density. In relation to the Atlantic case study, the literature has so far provided most guidance with regard to the link between forest management changes and the production of groundwater – both in quality and quantity. Changing from coniferous to broadleaved species increase the recharge of groundwater and also enhances the average quality of recharged groundwater.

We expect to assess the value of carbon sequestration outside the choice experiment in the stated preference study. The measure may be the annual additional amount of carbon which is sequestered based on the proposed management change. We expect to relate the amount (in tons) to the annual CO<sub>2</sub> production of an average household, or to the Danish Kyoto commitments at household level, in order to improve the communication by relating it to concepts which are well-known. There are direct carbon effects of most forest management actions, which can be assessed using standard growth models and expansion equations for soil carbon.

---

<sup>1</sup> Care must be taken when considering this broad statement as the characteristics of the soil, the climate and the forest itself can have a major effect on results.

### 2.1.2 Boreal region case

The Boreal case study concentrates on nature tourism and recreation in Ruka-Kuusamo region, North-Eastern Finland. Related to this kind of use, beautiful landscape and negative effects that commercial forestry may have on its enjoyability is one of the key attributes. For visitors in a forest, the more often they detect signs of strong management methods of forestry, especially clear cutting and reforestation combined with soil preparation practices, the lower are the recreational benefits they get from the forest. The levels of this externality can be qualitatively measured as follows, for example: the signs of strong management methods can quite often (enjoyability of landscape is at the present state), quite seldom (improves a bit), or never (increases a lot) be seen by the sides of hiking routes.

The second key externality of forests is biodiversity. In Finland, there are some 1500 threatened species and 37 per cent of them are primarily associated with forest habitats. One of the main factors that threaten species is changes in forests induced by modern forestry methods, also in Ruka-Kuusamo region. Although a complex concept, most obvious way to describe alternative levels of biodiversity could be the number of endangered species of animals and plants as follows: number of endangered species 150 (biodiversity is at the present state), populations increase so that the number of endangered species is 10% smaller than before (biodiversity increases a bit), and populations increase so that the number of endangered species is 30% smaller than before (biodiversity increases a lot).

Finally, the third key externality in the case region is carbon sequestered by forests. While growing forests store CO<sub>2</sub>, the most important gas effecting climate change. According to recent estimates on emissions, carbon sinks and forest C stocks (Anonymous 2009, Statistics Finland 2010) the average emission per capita in Finland is app. 15 ton CO<sub>2</sub>e. Latest studies in Finnish conditions indicate that by changing stand management, e.g. decreasing thinning and delaying final felling, we can substantially affect forest C stocks (including soil carbon). If we denote BAU management by 100% for average carbon sequestered in trees and soil (for Scots pine on dryish site type in southern Finland this would correspond to app. 3.5 ton CO<sub>2</sub> per annum), the range would be from 80 % up to 150% when management schedule is being changed (unpublished study).

### 2.1.3 The Mediterranean region case

Carbon sequestration will be measured in tonnes per hectare, using the same method as in PTGMF (Technical Forest Management and Enhancement Plan, officially approved by the Government of Catalonia – here is the first time the acronym is used). Such estimation comes from the biomass as calculated in the inventory multiplied by the

species factor as identified in the forest ecological inventory of Catalonia (Cervera et al, 2004).

Biodiversity will be measured as number of different plants in the stand, discriminating between main species and secondary species. This information is compiled in the inventories of the PTGMF for each management unit as well as the regular National Forest Inventories. We assume that fauna improvements will be correlated to the dynamics of the plant diversity indicators. Minor improvements in terms of plant diversity are foreseen to be achieved across the three scenarios, being possible to improve to the highest upgrading through the close-to-nature case, and an intermediate result with the moderate-intensity management.

In terms of recreational potential value, the study of Edwards et al, 2009 shows that for the Iberian Peninsula forest structure features determining mostly the recreational value are: visual penetration, presence of residues from silvicultural works in the forest and tree size. We will assimilate then visual penetration jointly with accessibility across the forest to the suitability for recreational uses through an adaptation of the model developed in the work of Blanco et al, 2009.

Recreation potential is supposed to be improved across the management scenarios in a slightly manner, being possible to reach a moderate enhancement through the moderate-intensity practices and even high increase throughout the close-to-nature model.

The desirable measure of the impacts regarding resistance to wildfires would be the number of dead trees versus the previous number of trees, as an indicator of post-fire survival. However, this indicator is not contemplated in current wildfire reports. Consequently we will have to constrain to the annual statistics of burnt surface.

#### **2.1.4 Mountainous region case**

Forests in mountain areas provide a joint set of externalities, whose complexity is difficult to simplify in elementary components, making externality measurement a hard task. Looking at the four different Newforex externalities in a mountainous region context, progress on the measurement of the externalities has proceeded at a different speed in the specific disciplinary fields, and we have now more information regarding some externalities – biodiversity (mostly species biodiversity), carbon sequestration, recreation – and less regarding other, especially water and landscape quality. Most of the work, however is in term of physical measurement units, while a comprehensive framework for the measurement of forest externalities in economic terms has been attempted less frequently, especially at site/project level. Significant operational work exists in the Mid-term and Final Evaluations of the Rural Development Programmes, but



most of the criteria and indicators developed in that case refer to the agricultural sector and not to forestry.

As regards the specific work to be undertaken within NEWFOREX, and especially in WP2, the mountainous region case study will consider the following externalities: (i) scenic view of forest management; (ii) Carbon sequestration; (iii) species biodiversity ( $\alpha$  biodiversity); (iv) landscape view; and (v) forest recreation. Water-related externalities, like effect on water quality and quantity, on prevention of floods and soil erosion are also important issues in mountain forest management and in mountain economy and policy, but, due to the insufficient understanding of the cause-effect relationships and to the lack of clear physical measurement units, we have decided not to consider water-related externalities in the mountain case study.

The first externality – ie scenic view of forest – is difficult to be measured by means of simple physical units, being actually a complex resultant of the application of different forest management choices: ‘clear cut and replanting’ models will produce a different look of the forest than ‘uneven-aged near to nature forestry based on selection cuts’. Therefore, more than ‘measuring’ it, we will represent this externality by referring to different typologies of forest structures, which in turn are the result of the application of specific forest management models. Basic attributes of these forest structures in terms of scenic view are the aspect and size of trees (either high forests or coppices), the distribution of forest canopy in one or more layers, the presence of undergrowth and of herbaceous and bushy layers, and the presence of dead trees and of residues of cuts on the ground: in the perspective of forest scenic view, all these attributes can be considered as impediments to visual penetration.

The second externality Carbon sequestration is measured with reference to forest growth converted in quantity of CO<sub>2</sub> sequestered by making use of species factors, of BEF coefficients and of stoichiometric relationships C/CO<sub>2</sub>. The most important data sources are the National Forest Inventory for forest stocks and increments and the CARBONMARK Project (<http://www.carbomark.org/>) for conversion coefficients from wood volumes to tonnes of CO<sub>2</sub>. This sequestering capacity will then be related to the annual Carbon emissions of one resident of the Veneto Region and expressed as the forest growth able to offset the emissions of n residents in the region.

The third externality, forest biodiversity, is meant in terms of species numbers ( $\alpha$  biodiversity). Thanks to the high variability of habitats in a relatively small area, Veneto region’s mountain areas are considered a biodiversity hotspot in Europe. However, habitat disappearance is such that the number of species is decreasing at a predicted speed of 50 species in the next 10 years (these numbers consider both fauna and flora species together and do not distinguish between different animal taxa). We will measure forest biodiversity by the number of endangered species that will disappear from the

forest ecosystems without putting in place adequate forest management and conservation policies.

Landscape view is also another important attribute of forests which is now deeply affected by land use policies but also, indirectly, by a large number of other drivers. The most diffuse perception/image of mountain landscape, especially in the Alps, is that of a balanced mixture of forest, open spaces mostly surrounding the villages (vegetable gardens, meadows and pastures) and of bare land (rocks and prairies) above the tree level. However, in recent decades, the trend is that of a modification of mountain landscape with reduction of open areas, due to a continuous process of recolonisation of meadows and pasture by trees. Therefore we will express the attribute 'landscape view' by means of the percentage of open spaces over total land area (forest+open space+bare land) at site level.

The fifth and last externality considered for mountainous forests is recreation. We will measure this through the number and density of touristic infrastructures for forest access and recreation. These are represented by footpath density, directional marks presence and density, and touristic facilities presence and density (like eg pic-nic areas, parking sites, pubs and toilets).

### **2.1.5 Central European region**

The biodiversity of the Białowieża Forest is a complex function based on: the successional stage of the ecosystem, the size of the area, and the internal and external forest connectivity.

Changing protection regime of the area outside the national park will have impact on each of the elements listed above. Enlarging protection area will not have impact on number of species present in the Białowieża Forest but it will increase the area where they live, and thus will impact endangered species population. For example in the BNP there are some species of fungi and insects, so called old-growth relics, extinct elsewhere that rely on specific kinds of decaying wood. Enlarging passive protection zone will in some time result in increasing supply of dead-wood and will increase the area where these species are present. There is a close link between volume of decaying wood and presence of some species. Currently the volume of dead wood in the managed forest is from 5 to 10 times smaller than in the strict reserve in the national park.

### **2.1.6 Developing country case**

We are here in a context of avoided deforestation. The key externality is thus the conservation of the forest carbon stock. It is approximated through changes in the forest land use: BAU deforestation minus observed deforestation. In this context, biodiversity



conservation is a joint product that could be measured by some usual biodiversity indicators (e.g, number of tree species, flora/fauna richness etc).

## ***2.2 Provision of key externalities in forest: the components of the cost of provision***

### **2.2.1 Direct costs**

Generally, direct costs, or implementation costs, correspond to the easiest measurable costs. They are linked to the undertaking of a specific management action for the provision of one (or several) public good(s): equipment for recreation, specific costs of management for maintaining (or restoring) biodiversity. The total costs incurred in the specific action for the provision of the public good include operation costs and/or investments (costs of capital). The former ones correspond to the variable costs of the good provision and cover expenses relative to variable inputs (e.g., labour, energy, materials). They are costs relative to the “maintenance” of the public good and spread all along the year. Actions that generate these costs have in general to be renewed each year. Instead, costs of capital are independent of the quantity of provided public good (in the short term) and concern investments realised for a key action for the provision of the public good (e.g., trail extensions or building of sanitary facilities, restoration of clearings or forest ponds). Among multiple investments, it is important to distinguish voluntary investments from the mandatory ones (which become an additional constraint for the producer).

In the context of forest management, externalities are expected to come along with the active management of the forest; therefore their direct costs could be derived from the necessary activities to achieve the desired levels. It's possible to establish a list of activities fitting with the scenarios presented in the valuation study that have been contrasted with experts. Direct cost could encompass regeneration management costs and forest enhancement costs (biodiversity and carbon), clearing and thinning costs (biodiversity and recreation).

### **2.2.2 Opportunity costs**

These costs are analyzed in terms of forest management or other land use choice (loss in timber income and costs associated with forgone land uses), i.e., relative to the “status quo” option: productivity loss, costs of inputs, harvesting quantity and frequency, timber prices, taxes, subventions...

#### **2.2.2.1 Definition of opportunity costs**

The opportunity cost is the benefit that can be obtained from an alternative use of the same resource. In our case, the resource is a piece of land and the uses are crops and/or

timber growing on it. The opportunity cost is the difference between the highest feasible returns that can be earned when managing a piece of land and the current management of the same piece of land. If we consider the preservation of a forest ecosystem in a piece of land where the best returns would come from agricultural activities, then the opportunity cost of the protection corresponds to the difference between the net returns from the most valuable agricultural management and the net returns from the management of the land as a forest. This 'opportunity cost' concept is applicable as well in the case of a trade-off between joint productions: in the case of two substitute products, any increase in the production of one product could lead to a reduction in the production of the other. Note that the determination of the relevant opportunity cost measure is subject to feasibility of alternative land uses and hence incomes from land. Not all land uses are feasible, for practical, ecological and judicial reasons, on all pieces of land.

The opportunity cost is not necessarily expressed in monetary terms. The opportunity cost of the production of environmental services, that are wood substitutes in forest, can be expressed in terms of the reduction in the quantity of harvested wood and the additional investments required to increase by one unit the production of the environmental service. This requires however that both outputs can be measured.

Forest and land management result from choices that are made in a set of many possible productions but that are not always measurable in monetary terms, as for example for the preservation of biodiversity. When possible, the use of opportunity costs is appropriate to analyze the impact of the choices in term of management.

### **2.2.2.2 Estimation of opportunity costs**

In the literature, the opportunity costs of ecosystem services are obtained using three main approaches: static cost-benefit analyses, dynamic modelling and econometric analyses. Grieg-Gran (2006) highlights that the opportunity costs of a land-use change could be estimated using the land prices as references. These land prices should reflect the discounted stream of returns from its most productive/valuable use. However, if the land market is not very developed then the market value can differ from the theoretical value. Therefore, Grieg-Gran (2006) calculated the difference of net present value of the land-uses to estimate the opportunity costs of avoiding deforestation in eight developing countries.

A second approach is based on mathematical programming. Borner et al. (2009) model the functioning of farms in Kenya using econometric data and expert knowledge. They then use an optimization process to estimate the shadow price of land for each farm. This shadow value represents the nominal opportunity costs of forest conservation which does not take into account the benefits from forests. The modelling approach is

also used in Juutinen et al. 2009 (see 2.3.1 and Box 1), to estimate the opportunity cost of conservation which is supposed to be equal to the maximum net present value determined with the Faustmann formula. They however noted that this forgone income from the land is unobservable in the reality and that, referring to Michael (2003), the actual opportunity cost can be lower than predicted one in the case of environmentally minded land-owners.

The last approach is based on the production possibility frontiers (PPF). Most publications on opportunity costs aim at determining the cost of protecting the land, either by changing the land-use from agriculture to forest or by changing the management target from wood supply to forest protection. These contrasted cases are the easiest to establish. However, many situations correspond to less strict tradeoffs. Moreover, the trade-off curve may be non linear. In this case, the opportunity costs vary from the initial production to the targeted production. Boscolo and Vincent (2003) traced the production possibility frontier and determined the trade-off curve between the net present value (NPV) from wood harvest and biodiversity or carbon storage. The opportunity cost of changing practices can be read on the PPF. Montgomery et al. (2002) and Nalle et al. (2004) also estimated production possibility frontiers, but they did not analyze the results in terms of opportunity costs; they focussed on the possibility to improve the management in zones where there was no trade-off and consequently no opportunity cost.

In most cases, the opportunity cost is not equally distributed over space. However, when planning large scale regulations or policies as in our case studies, opportunity costs are relevant at the landscape level and even at the national and international levels. In this direction, Antle and Valdivia 2006 used a stand level opportunity cost approach to derive a spatial distribution of opportunity costs of providing ecosystem services. Juutinen et al. (2008) used a similar approach to propose a cost efficient allocation of the land for both the protection of biodiversity and the production of wood.

We note that many studies on the behaviour of NIPF owners (see 2.2.1) highlight the fact that these forest owners maximize their utility rather than their net return. It is consequently important to analyze the opportunity cost of alternative land management practices in terms of a utility variation. Thus the identification of the utility function for the NIPF and the estimation of the opportunity costs of taking more care of forest externalities would make it possible to imagine some compensation mechanisms which may not be exclusively monetary.

### **2.2.2.3 Data needs**

To estimate the opportunity cost, there is a need for a clear understanding of the optimal production in the stand as well as a good knowledge of the different products that can be

concerned by the process. The more we know about the production process (and the production possibility frontier), the higher the quality of the opportunity cost estimates.

For each type of area (characterized by the soil, the climate conditions...) a description of the most productive practice must be established. This work is to be conducted using expert knowledge and field data concerning the stands and the existing practices.

In practice, the following data are required to conduct an opportunity costs analysis:

- Fertility of the stand (e.g. the dominant height at a specific age for the main species growing in the area);
- Biodiversity stakes (endangered species, rare species, and common diversity);
- Social stakes (recreation demand in the area: preferences and intensity of the demand);
- Water stakes and services provided by the forest (quality, low-flow, runoff);
- Carbon storage: biomass and carbon content in trees depending on the species and the size of the trees; soil carbon content directly measured or estimated using available results in similar stands and soils;
- Current status of the stand (volume, mean/dominant diameter, number of stems, structure, age...);
- A description of existing and alternative practices (species, revolution period, work done and related costs).

Growth models or production table (and even agricultural productivity information in case of land use change) are used to estimate the wood production and predict the changes of the stand composition and structure through time.

The relations between water quality and forest management intensity are complicated to estimate. One of the main results concerns the effect of permanent coverage compared to clear-cut regimes. The influence of the management depends on the location of the forests. A spatial approach at the watershed level can be conducted.

Since most methodologies rely on a benchmark, the higher the diversity of the management examples, the more accurate the results. Simulations with growth models of extreme management scenarios (non-management or very intensive management) usually produce poor results. We need then real examples concerning the scenarios that will be analyzed in the project.

**Box 1: Theoretical approach to assess opportunity costs related to forest externalities**

In principal we can determine the opportunity costs involved in providing a forest externality.

Theoretically, the cost of provision of a forest externality can be formulated according to the following equations:

$$C_y = NPV^* - NPV_y \quad [1]$$

where  $C_y$  = the cost of provision of forest externality  $y$ , €/ha

$NPV^*$  = net present value of the forest stand (including the soil expectation value and the current stumpage value) associated with business as usual, BAU management, €/ha (or, alternatively NPV associated with stand-level financial optimum)

$NPV_y$  = net present value associated with the management regime contributing to provide forest externality  $y$ , €/ha

Net present value, NPV was calculated according to the Faustmann rotation model modified to take into account the present status of the forest:

$$NPV = \sum_{i=b}^s (R_i - \sum_{k=1}^m c_{ik}) e^{-(i-b)} + \frac{\sum_{i=0}^s (R_i - \sum_{k=1}^m c_{ik}) e^{-ir}}{1 - e^{-rs}} e^{-(s-b)} \quad [2]$$

where  $R_i$  = cutting revenues, €/ha

$c_{ik}$  = silvicultural costs (when  $k=1$ ; then stand establishment costs), €/ha

$i = 0, \dots, s$  stand age ( $s$ =time for final cut)

$r$  = discount rate (2%, 3%, 4% tai 5%)

$b$  = the age of the existing stand

(Note: equation [2] modified from Hyytiäinen & Tahvonen 2001)

**2.2.3 Transaction costs**

Transaction costs (TC) in the literature were primary addressed to a private firm context by Coase (1960) who defines TC as “the costs of the price mechanism” (1937). From this broad definition, two approaches in the literature have been developed (Allen, 1991): the neoclassical definition treats TC as “costs of trading across a market” (Barzel 1985, Gordon 1994) and the institutional approach defines TC as “costs of establishing and enforcing property rights” (broadly determined by law, rules, social customs and organization). Demsetz (1968, 1988, 1995) combines an institutional definition “the cost

of exchanging ownership titles”; and a market-based one “the cost of coordinating resources through market”. From those definitions, TC classifications are made (Thompson (1999), Stavins (1995), Falconer and Whitby (2000)). Generally three main categories are considered according to the transaction time frame: research and information (before transaction), contracting (implementation during transaction) and policing (monitoring after transaction).

Allen (1991) insists on the definition to be used depends on the problem being addressed. Several studies focus on the environmental area: Griffin and Bromley (1982) for non-point water pollution, Stavins (1995) on carbon permits. Most forest externalities are not marketable (except carbon sequestration), preventing from directly relying on a market-based definition. Then either the willingness of private forest owners to provide externalities can be assessed or the costs of coordinating individuals and resources for the creation of institutional arrangement can be considered.

To assess TC, information on the type of collaboration or cooperation between suppliers is required especially the type of agreement (voluntary or compulsory), joint action (interdependency between decisions’ actors) or sum of individual actions; the duration of the agreement; the purpose of the agreement (environmental, production-based); the membership condition (open or restricted); decision rules (minimum participation or unanimity).

Time is frequently used as a unit of measure (times the average wage rate) (Vernimmen et al., 2000, Edgell, 1998, Kuperan et al., 1998, Fang et al., 2005). It can be measured through data from public records or through surveys from stakeholders (industries, institutions or individuals).<sup>2</sup> Case studies mainly concern two types of externalities: carbon sequestration (Stavins, 1995) and conservation (area protection), focusing on agri-environmental policies (Falconer and Whitby, 2000, Falconer, 2000, Fang et al., 2005).

## 2.2.4 Feedback costs: assessing joint-production characteristics

Feedback costs are the effects of the provision of a particular forest externality both on other externalities (more recreation and less biodiversity) and on other land uses (e.g., the protection of biodiversity in forest can be potentially damaging to some culture in agricultural lands). They require knowledge on the links between timber and non-timber benefits, between cross-effect of externality provision and forest owners’ valuation of externalities.

---

<sup>2</sup> Transaction costs may also be assessed as the difference between the buying and the selling price of a commodity in a given market (Stavins, 1995).

In our context, the feedback costs are an indicator of joint-production characteristics: to what extent does a management scenario aiming at improving carbon storage impact biodiversity? Does investment for recreational facilities have an impact on biodiversity? There is a general lack of empirical research of these questions as revealed by the information made available from the case studies in NEWFOREX.

### **3. METHODS FOR ASSESSING COST OF EXTERNALITY PROVISION: A REVIEW**

In this section we present a literature review on the methods for assessing the cost of provision of forest externalities in recent studies. The studies are reviewed according to four forest externalities: biodiversity, carbon sequestration, water and recreation, in the CSP's.

Two main approaches are considered. Technological approaches focus on outcomes and objective costs, while behavioural approaches focus on the forest owners' decision process and perceived costs.

#### **3.1 *Technological approaches***

##### **3.1.1 Bottom up engineering production approach**

The traditional approach to describe the forest management is the model of Faustmann (1849). This approach largely used by forest engineers consists of computing the optimal rotation date by maximizing the present value (i.e., the sum of discounted net cash flow over an infinite time period) of a single-aged timber stand. Hartman (1976) generalizes the Faustmann model by including values associated to standing trees (which could be externality values). This leads to a change in the optimal harvest timing depending on the nature of the forest services and timber value.

Numerous studies develop dynamic programming models to determine the optimal harvest decision for a forest stand taking into account externality services. In a very recent article, Asante et al. (2010) use this approach for a forest stand in the boreal forest of western Canada used to provide both timber and carbon sequestration. Carbon considered here is that stored in dead organic matter (DOM). Forest owners are paid for net CO<sub>2</sub> sequestration, and have to pay for net release, through a carbon market. It is found that the optimal decision is sensitive (i.e., the harvest age increases) to current stocks of carbon in the DOM pool, especially when carbon prices are high and initial DOM stocks are low, illustrating the substitutability between timber and carbon. However, a positive carbon price reduces the value of land, timber, and carbon sequestration services relative to the case in which the carbon price is null (which may



be considered as the Business as usual). This monetary loss could capture opportunity costs as well as feedback costs related to the loss of land value.

### 3.1.2 Multiproduct cost function

An accurate measure of non-timber outputs could make it possible to define a cost function for the joint production of timber and non-timber benefits (i.e., recreation, biodiversity, carbon, water quality). The technology could be well represented by a production function or by a transformation function in the multiproduct case, which links produced (private and public) goods and inputs. Nevertheless the cost function, the dual representation of the technology, is following McFadden (1978) a “sufficient statistic” since it captures all economically relevant information about the technology.

Different other approaches can be used to assess production costs. Among them, the shadow cost function approach is based on the shadow prices and allows for taking into account market imperfections. Shadow prices are usually modelled by scaling or translating observed prices. This method is also related to the stochastic cost frontier approach where a technical inefficiency component is isolated in the error term and can be estimated. The introduction of shadow prices makes it possible to distinguish allocative inefficiency from technical inefficiency.

The characteristics of timber production and of the provided externalities can give an unusual structure of the (neoclassical) multiproduct cost function (Bowes and Krutilla 1989). Indeed, some environmental services can be produced at no variable costs as a result of natural forest growth (e.g., carbon sequestration), whereas other ones such as biodiversity are less compatible with industrial production of timber (including clear-cutting). Moreover, the costs associated to harvesting are a major component of overall costs, and harvesting practices strongly influence the provision of other services.

To the best of our knowledge, there is no recent article on the domain of forest dealing with this methodology (Hof et al, 1985). However, multifunctional agriculture offers a few studies of interest using the concept of joint production of commodities and environmental goods.

In a theoretical paper, Le Cotty and Voituriez (2003) interestingly distinguish between the provision of a joint public good (e.g., biodiversity conservation, landscape) with an agricultural output, and the provision of a public good produced as an externality of agriculture (e.g. prevention of erosion in desertifying areas). In the first case a standard multi-output cost function is modelled and economies of scope can be computed. In the second case, the externality of the agricultural output  $y$  is written  $x(y)$ .

Peerlings and Polman (2004) investigate the joint production of milk and 'wildlife and landscape services' on Dutch dairy farms using a micro-econometric profit model of



individual farm behaviour. They use the financial compensation paid to farmers (for restrictions on farming practices) as a proxy of the production of wildlife and landscape services. From the estimated profit function, it is possible to calculate the costs of producing a fixed level of milk and wildlife and landscape services jointly and separately, and also to deduce measures of scope economies.

Havlik et al. (2005) analyse the joint production of one commodity, beef, and one non-commodity, grassland biodiversity. The amount of environmental good is approximated by the number of hectares managed in a prescribed way. Compliance with agri-environmental requirements (on a particular number of hectares) is a constraint of the model. The marginal cost of producing the relevant environmental good is then deduced from the shadow price of this constraint. A mathematical programming farm-level model is used to analyse the impact of commodity-linked policy instruments on the quantity of biodiversity produced by cattle or dairy farms.

### 3.1.3 Contingent market

One example of methods related to the estimation of cost of providing a forest externality is the study by Figuepron et al. (2009). The aim of this study is to give a monetary value to the service provided by the forest in terms of increasing water quality. The used approach is to quantify the impact of forests on water quality by measuring variations of the water prices on the water supply market. The price is a proxy of the marginal cost of supplying drinking water. The main hypothesis which is tested is that the difference between treatment costs is related to the origin of raw water (forest or not). This (negative) difference in cost of water supply can be interpreted as the (positive) value of the forest service. Given the variability of links between forests and water quality, it has been chosen to cover the whole of France on the basis of common and observed data in each administrative department. Data were collected both on water supply management (price, technical variables of service, management mode) and on land use (including the proportion of departmental woodlands, agricultural uses, etc.). An econometric method based on the estimation of a simultaneous equation model is implemented. This system comprises one equation for water price, two for raw water quality indicators (pesticides and nitrates) and one on the management regime of water supply services. Estimation results showed that the forest had a positive effect on raw water quality compared to other land uses, with an indirect impact on water prices, making them cheaper for consumers.

---

## 3.2 *Producer/owner behaviours and preferences*

In the forest economics literature, there are essentially two types of behaviours among private forest owners that are studied (Singh et al., 1986, Binkley 1981, Pattanayak et al., 2002): Industrial owners manage their forests as profit-maximiser. In this case, the

Fisherian separation of consumption (amenity services and others personal consumption) and production (timber) is respected. Non-industrial owners produce timber and externalities, also consuming these latter ones. Their production decisions are then not separated from their preferences or their utilities. Thus those preferences do influence the perceived costs of providing public goods.

### 3.2.1 Industrial private forest owners

The industrial forest owners manage their forests solely for timber production. Their objective is to maximize the benefit of their forest holdings regardless of their preferences. The timber supply function of these owners depends on the structure of their properties (ages, species), their management efforts, the quality of land and the timber price (Newman and Wear, 1993). The optimum age for harvesting on these properties is obtained by the Faustmann's method (1849).

If forest land use is the optimal one, then any action for externality provision affecting the logging profit is perceived as a cost by the owner. This net loss of profit is the opportunity cost (see 1.2.2) of the proposed action. Therefore, the opportunity cost of externality provision for an industrial private forest owner is the net loss of profit that generated by the action, compared to the profit from Faustmann's optimal rotation. If forest land use is not the best alternative, then the opportunity cost is the difference between the profits from the optimal use of land (e.g.: agriculture) and from the land use implied by externality provision (e.g.: forest).

### 3.2.2 Non-Industrial Private Forest (NIPF) owners

Using the household model of Becker (1965), Binkley (1981) showed that Fisher's theorem is not valid due to the valuation of externalities by owners. In addition, a two-period model has showed that, because of price uncertainty, capital markets are imperfect. The Fisher separation theorem then does not hold (Tahvonen and Salo, 1999). Thus, forest management decisions depend on forest owners preferences (Hartman, 1976; Binkley, 1981).

The non-industrial forest owners produce timber and consume forest services. Therefore, they maximize their utilities taking into account the profit from the sale of timber and forest services they wish to consume (tradeoffs between wood and non-wood). Each owner has an optimal combination of goods and services that maximizes his utility. This combination depends on his personal characteristics: preferences, income, location, bequest intention, etc. (Binkley 1981, Pattanayak et al. 2002). The opportunity cost of supplementary externality provision for these owners is the profit loss caused by this provision. It is expressed in terms of utility of foregone income and not directly in monetary value. Therefore NIPF owners opportunity cost depends on

their characteristics. Non-timber goods and services supply varies from one owner to another and is generally not marketed.

If forest land use is the optimal feasible alternative, this opportunity cost can be viewed as a lower bound of the value of the externality provided, since it does not consider its social value. If forest land use is not the optimal alternative, then the opportunity cost is the difference between the utility of income from the optimal use of land (e.g.: agriculture) and from the land use implied by externality provision (e.g.: forest).

The revealed preference method allows measuring the opportunity cost of production of non-timber. It uses observations on how decision makers trade off timber production and externalities (Raunikaar and Buongiorno, 2006, Lee, 1997 and Scarpa et al., 2000). In these studies, the authors assumed that the forest is the optimal use of land. So the opportunity cost is calculated relative to the maximum profit from logging.

Raunikaar and Buongiorno (2006) examine revealed willingness to pay of southern US NIPF owners. They consider the externalities of mixed age and mixed species forest, compared to the one of the less natural, but more profitable, even-aged loblolly plantation. The opportunity cost of externality provision is the income that owners are willing to forgo to maintain natural stand instead of converting them to more profitable plantations. They find that the average NIPF owner in the south central region of the United States was willing to incur an opportunity cost of \$149 ha/year for the externalities of naturally regenerated mixed age loblolly hardwood forests. The externality value was higher on public land (average= \$200 ha/year) than on private land. This was expected since managers of public land care for more public goods than managers of private lands do.

Scarpa et al. (2000) estimate the non-timber value (NTV) of uneven-aged northern hardwood stands to forest owners. They consider that the value should be at least equal to the difference between the income of their actual management and the most profitable alternative. The Markov decision model was used to predict the income of the most profitable alternative. Then, they applied the hedonic regression to determine how the biophysical characteristics of stands and the socioeconomic setting influenced NTV. They find that the average non-industrial private forest (NIPF) owner is willing to forgo \$25 ha/year in timber profit for the improved externalities obtained with a more conservative management.

Lee (1997) uses the hedonic method to study the revealed preference of NIPF owners for non-timber externalities of uneven-aged southern pine stands. Lee (1998) uses the hedonic method to establish a relationship between externalities and wood supply from private forest owners. The forest characteristics (tree diversity, scenic beauty, wildlife etc.) are seen as proxies for externality values for the owner. The forest owners' decision

of harvesting or not is considered as a market decision. In this case, the cost of postponing the harvest beyond Faustmann's optimum harvest age reflects the market value of forest externalities for the owner.

### ***3.3 Stated and revealed preference approaches***

Stated and revealed preferences can be developed to estimate a value for key externalities in forest. Stated preference methods are based on a direct asking to forest owners for the compensation level they would require in case of a greater effort to produce more externalities. These methods are essentially defined by the contingent valuation one and by the choice modeling approach. In the contingent valuation method, a variation in the level of the chosen externality is estimated in terms of a monetary value, generally the willingness to accept of the forest owner engaged to provide it. The choice modeling method gives to the respondent the choice between several attributes of a good or of a process (management and impact on externalities). Then estimates for each attribute is derived in monetary units. Applications to forest owners with an objective to increase biodiversity, recreation or carbon sequestration are now developed (see the CSP's and Matta et al, 2007; Gadaud et Rambonilaza, 2010; Shaikh et al, 2007). Revealed preference methods are based on some observed prices, either in the travel cost method (the measure of the expenditures for visitors) or in the hedonic price method (sale prices of properties). In general these methods are more developed in the demand side, to determine the value of recreation in forests or the value of urban forestry (Tyrvaenen, 1997). Some applications of these methods in the forest sector and from the forest owners' cost of providing are given in the section above.

### ***3.4 Application to the Case Studies***

Measures of provision and provision costs do not exist for all the externalities in all the case studies. Indeed data may be missing or some externalities may not be relevant for a particular case study. For instance, in the Boreal region, possible joint production options of forest externalities relevant for concentrate on three forest externalities, which are important from the national perspective. These forest externalities are: biodiversity, recreation (nature-based tourism) and carbon sequestration. In each of the joint production options timber production was set as counterpart for one particular forest externality. This is due to the following. First, a detailed study of trade-offs between management options related to timber production and alternative forest externalities requires stand level analyses (see, Pohjola & Valsta 2007, Miina et al. 2010, Cao et al. 2010). Through stand level analyses we can capture the essentials affecting the trade-offs between alternative productions chains associated with single stands.

Focusing on the Atlantic case study, previous studies considered biodiversity, recreation and water quality. Existing studies in the Boreal region and the Mediterranean region dealt with biodiversity, recreation and carbon as well. The Mountainous case study focused on water regulation and soil erosion. Finally, the developing country case considered carbon and water-related services.

### **3.4.1 Biodiversity**

#### **3.4.1.1 Atlantic urbanised case**

In the Atlantic case, the costs of providing environmental goods and services from forest and nature areas have been investigated through different methods which mainly relate to theoretical ways of assessing the cost of changes through forest management planning tools, typically addressing the quantification of shadow costs. A few studies instead focus on methods which aim at eliciting landowners (perceived) costs of supply based on stated preference methods. Strange et al. (1999) develop a multiple-use forest management decision tool for insect control activities for a case area in Poland. The model uses a linear programming approach to optimize over socio-economic values; it incorporates the financial timber value, the value of non-market outputs and the social value of carbon storage and recreational benefits. They specify that the use of decision support methods should be closely linked to the specific planning situation, but the method may also be relevant for planning in relation to harvesting, afforestation and valuation of forest types. Brukas et al. (1999) also use a linear programming approach for multiple-criteria forest management decision making as opposed to focusing only on timber output. This paper suggests a method for public participation in the decision making technique exemplified through a case study in Lithuania. Strange et al. (2003) compare different multi-criteria optimization techniques (mixed integer programming, simulated annealing and genetic algorithms) when choosing the most appropriate areas for forest conservation. The methods use trade-offs between costs and benefits of supply based on opportunity costs and connectivity of areas and proximity to swamps. Near-natural silvicultural management regimes have been found to promote important ecological functions in the forest and enhance the biodiversity. The economic benefits or costs of near-natural silvicultural management regimes in beech have been investigated by Tarp et al. (2000) who determines under which conditions these regimes are economically superior to traditional clear felling. In a pure afforestation context, the paper by Strange et al (2002) applies a cellular automaton to optimise the provision of a set of externalities using spatially explicit aggregation of measures of, e.g. amenity values related to open land and forest views.

Paillet et al. (2010) have made a meta-analysis of 49 studies regarding the difference in biodiversity levels between managed and unmanaged forests. They find that species richness is slightly higher in unmanaged forests and that this difference increased over

time. Increasing the area of broadleaved trees has had a positive effect on biodiversity in coniferous areas (Patterson, 1993; Humphrey et al., 1998) and it also leads to greater diversity in fungal (Humphrey et al., 2000) lichen and invertebrate species (Humphrey et al., 1998). Quantitative effects of forest management changes on carbon stock have been assessed by Hyvönen et al. (2007).

### 3.4.1.2 Boreal region case

Juutinen et al. (2004) analyzed cost-efficient conservation of boreal old-growth forests by applying three alternative site selection criteria : an integrated site selection model (benchmark), ecological and penny-pincher models. All models were based on the presentation of chosen ecological features in a restricted optimization framework, assuming that each stand had only two management options: either to be clear-cut or completely preserved. The number of species was applied as a surrogate for overall diversity. An opportunity cost of establishing a reserve (conservation) was determined for each selection model (integrated, ecological and penny-pincher) by varying total budget. This budget constraint can be interpreted as the maximum amount of funds allowable for a conservation network. The opportunity cost was primarily determined at stand level and expanded to cover landscape level by applying a forestry model MELA (for further details on MELA software and its applications, see, e.g. Matala et al. 2009). The main results indicated that the distinctively largest number of species covered by the lowest opportunity costs involved in conservation was obtained with the integrated model. However, the trade-off between the number of species represented and the opportunity costs highlighted that it is increasingly expensive to cover the last few species.

Ahtikoski et al. (2007) assessed which type of conservation (permanent, temporary with different time spans) would result in the lowest loss in timber income (at present value) when providing biodiversity services. The analysis was based on a single stand assessment of an unmanaged 65-yr old Norway spruce forest stand on a herb-rich site type in southern Finland. The stand was described to be a good representative for Trading in Natural Values, TNV system applied in Finland. In the financial analyses the losses of timber incomes were determined for permanent conservation, 10-yr or 20-yr temporary conservation options. Tree growth and associated decay dynamics were simulated by a stand simulator MOTTI, and the financial analyses were based on the Faustmann rotation model solely at stand level. As anticipated, the 10-yr conservation had the lowest present values of losses in timber incomes, but at the same time the biodiversity index associated with the 10-yr conservation was distinctively the lowest, compared to 20-yr or permanent conservation (Ahtikoski et al. 2007). The present values of losses in timber incomes ranged from 1 780 € (10-yr conservation and 2% discount rate) up to 15 605 € (permanent conservation and 4% discount rate) per hectare.



Siikamäki & Layton (2007) developed site-level estimates of the opportunity cost of protecting biodiversity hotspots. A survey of non-industrial private forest owners was conducted, and landowners were asked whether their forests included areas eligible for the conservation program. The authors estimated the opportunity cost of protection for each candidate site. The main results indicated that incentive payment programs (IPPs) could achieve conservation targets in surprisingly cost-effective manner. Juutinen et al. (2008) estimated whether it would be more cost-efficient to buy or lease forest stands possessing valuable environmental characteristics on privately owned forests in producing biodiversity services. The purchase price for government acquisition of land was determined using the Faustmann model. The costs of land leasing were based on actual payments of the stands. The analysis included also transaction costs associated with land acquisition. The main results indicated that the direct costs of land purchases were lower than the direct costs of land leasing when the interest rate was less than 3%. However, in general the land purchasing and leasing resulted in quite similar cost levels

Juutinen & Ollikainen (2010) analyzed the performance of competitive bidding (a simulated biodiversity auction model), and compared the results with actual bids in the Trading in Natural Values, NTV program in Finland. The Faustmann rotation model was applied in determining the present value of returns from all future rotations, and this information was used in the simulated biodiversity auction model abreast with the inventoried properties of the stands (ecological values). The results showed that actual bids were on average 400- 1200 € lower per hectare than the bids generated by the biodiversity auction model.

Related to the costs of provision of non-timber benefits of forests, forest owners' perceptions of costs may be important. In the beginning of 2000's, a new market-based voluntary programme aimed at preserving forest habitats on private land has been implemented in Finland. This scheme, called Trading in Natural Values (TNV), is based on conservation by fixed-term agreements between forest owners and a governmental authority. According to these contracts the forest owners produce biodiversity services on their lands and receive a compensation payment. In this context, several studies have analyzed different aspects that are close to the costs, i.e. compensation policy required, organization of the compensation policy, amounts of claims or willingness to accept compensation, etc. One of the objectives of the study by Horne et al. 2009 was to examine the attitudes of Finnish non-industrial private forest owners towards the safeguarding of forest biodiversity voluntarily, its socio-economic effects, compensation policy and policy instruments. Forest owners thought that the best way to determine the amount of compensation was an offer made by the landowners themselves and monetary payment was the most acceptable form of compensation, whereas land exchange and tax reduction were less popular alternatives. Full payment at the beginning of the contract was clearly most popular

Using Choice experiment method, Horne (2006) examined in the context of TNV the factors that affect the acceptability of biodiversity conservation contracts among private forest owners, and the amount of compensation needed to keep the forest owners at least as well off as before the contract. The analysis shows that the terms of the contract are of great importance to forest owners as the demand for compensation rises manifold with undesirable factors. The base scenario of the welfare analysis was selected to have the forest owner as the initiator of the contract, the contract binds a new as well as the present forest owners, small patches are protected, and the duration of contract is 10 years. In this base scenario the impact on forest owners' welfare is -224 euros per hectare annually. A recent study by Juutinen & Ollikainen (2010) found indicates of the presence of strong conservation motives among the Finnish forest owners.

Mäntymaa et al. (2009) examined the characteristics of forest owners and their properties that indicate the owners' willingness to participate in the TNV programme. In addition, they analysed factors affecting the real compensation claims. The study used a dual set of data from the programme, i.e. one data set supplied by the authority of the programme and another collected with a survey from the owners involved in the project. The results suggest that to increase the participation rate, information on the conservation project should be targeted in particular to the forest owners who either emphasize financial investment as a motive for forest ownership, have positive attitudes toward nature protection, or own large amounts of forest property. Additionally, owners' positive environmental preferences would decrease and high harvesting value and high ecological quality of a preserved forest stand would increase compensation claims. Consequently, voluntary conservation programs may induce lower costs than traditional obligatory programs, such as a land taking. The voluntary programme could not, however, circumvent owners' strategic behaviour with respect to the claims.

### 3.4.1.3 The Mediterranean region case

Biodiversity has been dealt not from the point of view of enforcing forest management to achieve more mature stands, but instead to conserve those rare mature stands and their related fauna and flora. Biodiversity has been traditionally considered as an external imposition to forest owner given the trade-off with the productive objective of such mature forests. Therefore biodiversity cost has been equalled to the lost revenues for certain practices, generally the entire harvesting. According to the initiative of Forest Reserves in Girona (Diputació de Girona. 2010), such cost is calculated as the expected income according to the PTGMF.

We find that in practice certain protected species (*Merops apiaster*) is enhanced through a subsidy for compatibilise the activity of beekeepers, given that this species feeds on



honey bees (*Apis mellifera*). Value of the species is given by the estimated lost incomes, which depends on the bird abundance in the area (BOGC, 2007).

Other study in the area has found the optimum management plans for fitting the timber objective with habitat conditions of an endangered species, undertaken by Palahi et al, 2004. This study takes place in Catalonia, but in the Pyrenees, being the values then not applicable to our case study forest.

#### 3.4.1.4 The Mountainous region case

When talking of cost of provision of forest externalities, it is important to lay stress on the fact that Alpine forests – at least the Southern slopes of the Alps – are characterised by a high degree of multifunctionality, where market goods and environmental externalities are joint outputs of multipurpose forest management practices (Gios, 2008). The concept of forest multifunctionality, therefore, underpins all discussion of the Mountainous case.

A conceptual and theoretical framework for better understanding the multifunctional trade-off relationships between provision of private and public goods in agriculture and forestry has been identified by the STEWPOL Project. This project was based on the Production Possibility Frontier and emphasised the joint production nature between traditional market goods (e.g. food and fibre) and environmental externalities (landscape, recreation, environmental quality). The STEWPOL Project has been developed along the research works of Bowes and Krutilla (1989 pp. 57-58) and Bonniex and Desaignes (1998, p. 24). Although the approach has some limitations, as described in by Gatto and Merlo (1999) and refers mainly to an agricultural and not to a forest context, it is briefly presented here as a useful taxonomic tool in the context of the WP3 objectives.

The most important point stressed by the work is that, in relation to cost of provision, the relationships between market goods and externalities is not always and not necessarily one of competition, but also, to some extent, one of complementarities (in accordance with the so-called “Wake effect” or “Kielwasser Theory” theory - Rupf, 1960) or of indifference. These relationships are explained in the Table below.

**Table 2: Jointness levels between market goods and environmental goods**

Jointness level between traditional market goods and environmental goods and services	Economic nature of environmental goods and services	Type of environmental good and service produced

Maximum complementarities (Wake effect theory)	Environmentally-friendly practices can be meant as inputs of the production function of traditional market goods, originating environmental goods as unintended by-products	Drainage (water regime regulation), erosion control, landscape maintenance
	Mainly/only product, with traditional market goods becoming by-product (and input to the production of ERGS's)	Conservation and wildlife services, parks, recreational areas, wildlife service, all benefiting from a certain level of active management, e.g. timber exploitation and farming
Complementarity	Unintended by-product with nil marginal cost for the production of traditional market goods	Landscape quality, some practices producing biodiversity
	Environmental goods are the main product of the activity, while traditional market goods become incidental by products	Agri tourism
Substitution – trade offs	Products competing with production of traditional market goods	Hedgerows enhancing landscape and biodiversity, picnic areas, recreation paths

A recent work aimed at understanding motivations that induce farmers in the Veneto Region to enter agri-environmental measures has been published by Defrancesco et al. (2008). By using discrete choice models, the paper has tried to explore the factors conditioning the adopting or non-adopting behaviour. The paper has shown that the most reluctant to implement agro-environmental practices are highly-educated and relatively young market-oriented farmers planning to invest in the future in their farm business. On the other hand, most active adopters of agro-environmental practices are elderly farmers, with a traditional, more extensive approach to farming, with generally no successors to run the farm and income needs not strictly related to farm activities. Some young, environmental protection-oriented farmers, trying to integrate the provision of environmental goods into their activities by organic farming and/or farm diversification, are also part of this group.

### 3.4.1.5 Developing country case

For the estimation of opportunity costs of forest conservation in the Brazilian Amazon, two strains of methods based on cost-benefit analyses have recently been used to estimate the provision costs of public goods, mainly reduced emissions from deforestation (RED) and biodiversity co-benefits. The first approach is based on municipal land use statistics that are overlaid with spatial information on forest biomass, emission factors, and deforestation rates (Börner & Wunder, 2008; Börner *et al.*, 2010). The second approach is based on crop growth and land use change simulation modelling partially relying on the same data sources (Nepstad *et al.*, 2007). The findings

of these studies are reported in R\$/ ton CO<sub>2</sub> and C, respectively, leading to similar conclusions about the average provision costs of RED (see Figures 1 and 2).

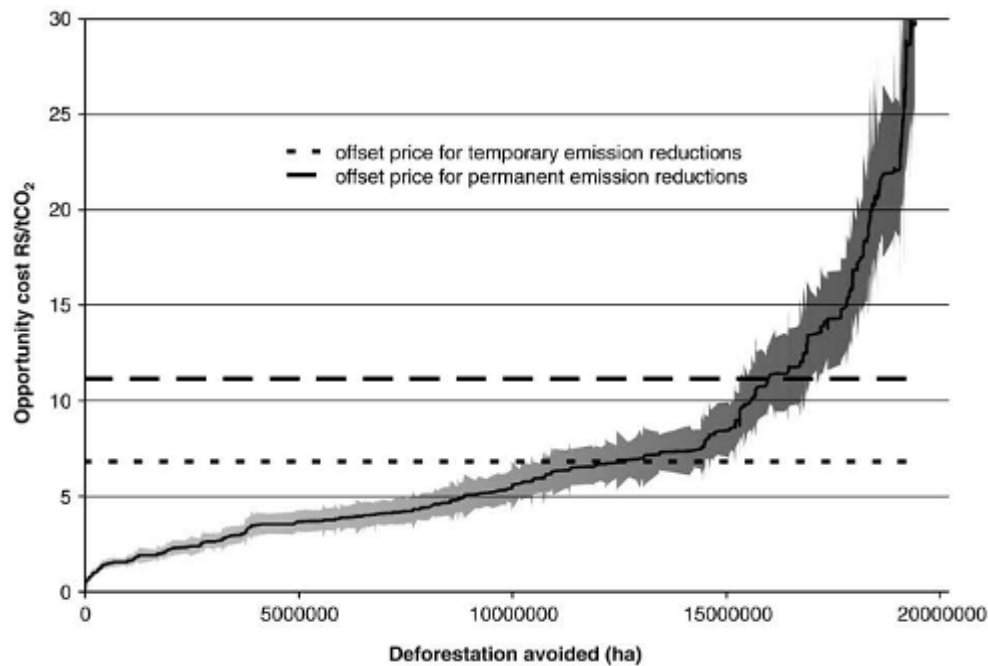


Figure 1: Avoided annual deforestation cost curve for 2009-18. Grey band = values within 5 – 95% sensitivity range ; Source: Börner *et al.* (2010)

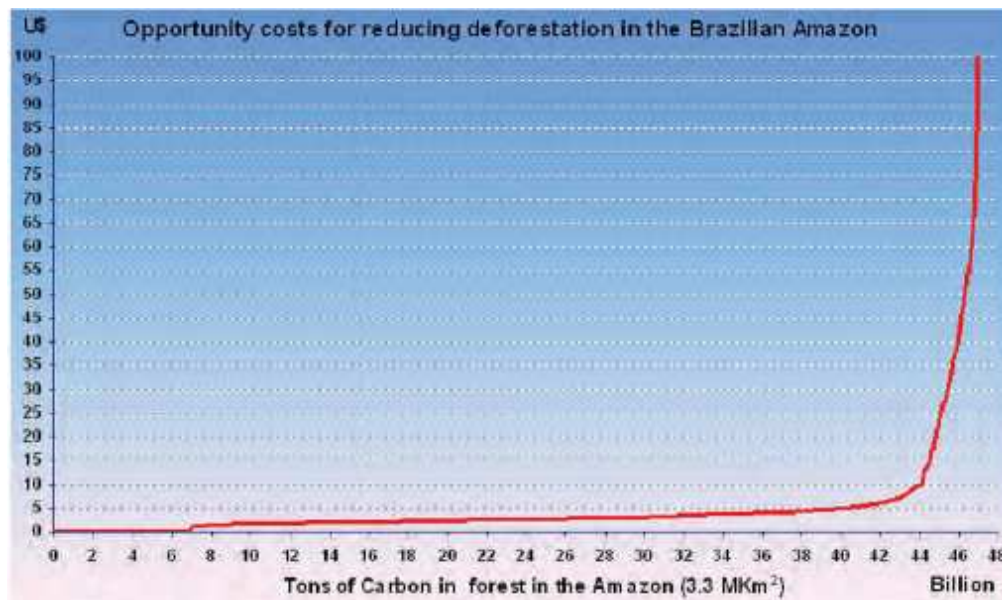


Figure 2: Avoided deforestation cost curve for the entire remaining forest area (3.3 M km<sup>2</sup>); Source: Nepstad *et al.*, (2007).

Though essentially delivering the same message, the two figures are not directly comparable as Fig. 1 reports provision cost only for high forest pressure areas of the size

equivalent to average historical deforestation rate, whereas Fig.2 covers the whole remaining forest area in the Brazilian Amazon. Nevertheless, both reconfirm the notion of a 'kinked' mitigation supply curve: the bulk of carbon loss from deforestation comes at low opportunity costs (from activities such as slash-and-burn agriculture and land-extensive cattle ranching), whereas a minority of activities are providing significantly higher (per-hectare and per tCO<sub>2</sub>) returns: modernized intensive cattle ranching, soy, perennial crops, palm oil, etc. – which would thus also be difficult to 'buy out' from a REDD point of view.

### 3.4.2 Recreation

#### 3.4.2.1 Atlantic urbanised case

The cost of providing recreational goods and services is a bit more complex as it is coupled to the preferences of the users/buyers and often very specific activities. The cost of providing recreational services can be assessed in different ways depending on the recreational activity but the activity will in most cases have to be narrowly defined. In some cases the costs for the supplier are related to establishment whereas in other cases they are related to damages/impacts from recreational activities. An example of the latter is Rusterholz et al. (2009) who describes a method for assessing the reduction in timber value arising from recreation in two suburban forests in Switzerland. With regard to recreational use by the general public, the costs are related to maintenance of hiking trails or other facilities related to general use such as benches, picnic sites and dustbins. More specific activities which still are widespread in Danish forests could be horse riding and the related cost would be maintenance of specific trails for this activity. In other words, the costs of many recreational services arise from direct costs of management and maintenance and would be found in the statement of operations for the enterprise.

Studies have shown that forest owners have different attitudes and management objectives (Boon and Meilby, 2007) which affect their attitudes as producers of environmental goods and services. According to Boon (2003) and Boon et al. (2004) forest owners can be divided into at least three types: the classical owner, the hobby owner, and the indifferent farmer. The classical owner owns more forestland and is financially motivated, but as he has a strongly felt and fairly diverse set of values attached to his ownership ; he will only react to financial instruments to the point where he feels that the relative loss on other objectives are fairly compensated. *The hobby owner* is motivated by his basic interest in the forest more than financial incentives. The *indifferent farmer* is the type most difficult to motivate, as he is less explicit about his goals. This type is more closely connected to agriculture than the other owner types.

In relation to recreational access, forest owners may also be divided into different types regarding their viewpoints on increased access and whether they require compensation for this or not (Urquhart et al, 2010; Church and Ravenscroft, 2008). Moreover, Urquhart et al. (2010) also finds that especially new and farmer woodland owners are more willing to provide conservation than other types of forest owners.

In a recent stated preference study of Danish landowners' willingness to accept various forms of afforestation contracts, Broch and Vedel (2010) finds that if the purpose of afforestation is to be recreational access for the general public, the willingness-to-accept compensation increases significantly, relative to purposes like groundwater protection and biodiversity protection (see also Vedel et al 2010b).

### **3.4.2.2 Boreal region case**

In forest ecosystems there are tradeoffs between timber production, recreation, biodiversity, carbon sequestration and possibly water quality (Nalle et al. 2004). Thinning (and particularly clear-cuts) influences greatly a forest's recreational value as these are highly dependent on the visual appearance of the forest (e.g. Silvennoinen et al. 2001, Tyrväinen et al. 2003, Nielsen et al. 2007).

Ahtikoski et al. (2010) surveyed the trade-offs between nature-based tourism and traditional forestry. They applied three alternative land-use scenarios where the level of integration between nature-based tourism and forestry was changed. The underlying idea was to determine how many more tourists per annum would compensate for the loss in annual timber revenues when outdoor recreation is taken into account in forest planning and management. The study framework was primarily based on stand projections (MOTTI stand simulator), but the economic as well as scenic analyses were conducted in a landscape level. The annual cutting removals (from individual stands) according to alternative land-use scenarios were further fed into regional input-output, I-O analysis. The effects of taking outdoor recreation into account in forest management at landscape level were then calculated with respect to value added and employment. The study demonstrated how the value added and employment of integrating nature-based tourism and forestry could be assessed through an application of combining stand projections and regional input-output, I-O analysis. The study area was located in northern Finland between two top-rated ski resorts, Ylläs and Levi. Total area coverage was 7 800 hectares of which app 5 6000 ha were forestland (annual net growth > 1 m<sup>3</sup>/ha). The main results indicated that reasonable (i.e. achievable) amount of increased tourists per annum is required to offset the losses due to restrictions in traditional forest management (since outdoor recreation is taken into account in management). Further, the results suggested that in areas where there is an established and strong tourism demand, the net costs of providing the adequate landscape quality for tourists in forested landscapes seem to be less than the net benefits derived from that action.



### 3.4.2.3 The Mediterranean region case

To our knowledge, the only study in the Mediterranean case is that of Flores Velasques et al. (2008) where they valued the scenic beauty linked to the recreational use in a *Pinus sylvestris* forest in Central Spain. Enhanced scenarios gathered actions improving recreational facilities, fire prevention and the follow-up of a few biodiversity indicators

	Mushroom price (€ kg <sup>-1</sup> ) for marketed/nonmarketed mushrooms			
	0/0	5/0	10/0	10/5
<i>P. sylvestris</i> (1,200 m, east)				
SEV (€ ha <sup>-1</sup> )	432	2,022	3,704	6,461
SEV timber (€ ha <sup>-1</sup> )	432	385	193	-267
SEV mushroom (€ ha <sup>-1</sup> )	0	1,637	3,511	6,728
Rotation length (years)	105	95	107	121
Wood production (m <sup>3</sup> ha <sup>-1</sup> a <sup>-1</sup> )	3.6	3.7	3.4	2.9
Mushroom harvest (kg ha <sup>-1</sup> a <sup>-1</sup> )	5.6	5.9	6.9	20.3 (7.7)
<i>P. nigra</i> (900 m, north)				
SEV (€ ha <sup>-1</sup> )	-31	367	761	3,131
SEV timber (€ ha <sup>-1</sup> )	-31	-42	-54	-742
SEV mushroom (€ ha <sup>-1</sup> )	0	409	815	3,873
Rotation length (years)	135.0	130.0	125.1	205.5
Wood production (m <sup>3</sup> ha <sup>-1</sup> a <sup>-1</sup> )	3.2	3.3	3.3	2.0
Mushroom harvest (kg ha <sup>-1</sup> a <sup>-1</sup> )	1.38	1.45	1.48	19.2 (2.5)

Slope is assumed to be 20%. When the price is 10€ kg<sup>-1</sup> for marketed mushrooms and 5€ kg<sup>-1</sup> for nonmarketed (price combination 10/5), the mushroom harvest includes also nonmarketed mushrooms (the harvest of marketed mushrooms is shown in parenthesis).

to control the trade-off tourists-protected species. See attached table to check the results. Values in the table attached.

Directly related to the recreational activity of mushroom picking, we found the study of Palahi et al.(2009) simulating the trade-offs of including the objective of mushroom production within the forest management of *P. nigra* and *P. sylvestris* stands in central Catalonia. Increased Soil Expectation Value due to optimal combinations of timber-mushroom goals would assimilate to the cost of enhancement

Table 1: Effect of the price of edible mushrooms on the optimal management schedule of a *P. sylvestris* and a *P. nigra* stand (Palahi et al, 2009).

## 3.4.3 Carbon

### 3.4.3.1 Atlantic region case

While the carbon sequestration potential of the forest management actions considered in the Atlantic valuation study of NEWFOREX is small, there are analyses of the sequestration potential of forest management actions, notably afforestation, in Denmark.

Anthon et al (2003) assess the carbon sequestration potential of larger set of forest management actions, including afforestation as well as rotation age prolongations and increased sequestration in current forest stands. They also assess marginal cost of provision in terms of opportunity costs of deviating from the optimal forest management or replacing agricultural land uses. While the physical potential at best can

only account for 5-10 % of the Danish Kyoto commitments over a period, several of the actions are of interest as they can provide the carbon sequestration at low, or even negative, social costs. The latter is true when other environmental co-benefits notably from afforestation is taken into account too.

### **3.4.3.2 Boreal region case**

Pohjola & Valsta (2007) determined the optimal combination of thinning and rotation period for joint production of timber and carbon sequestration with alternative carbon prices at stand level. The objective function for the private forest owner was to maximize the discounted net returns over an infinite time horizon (a modified Faustmann rotation model including logging costs). Technically, the authors applied the SMA (stand management assistant) software to optimize stand management with respect to the discounted net returns. The optimizing algorithms in the SMA software were based on so-called direct-search algorithm with neighbourhood and random search elements included. The data consisted of 10 Scots pine and 7 Norway spruce stands in south-central Finland. The main results indicated that including carbon sequestration into the stand management increased the incomes to forest owner considerably, when the subsidy level for ton CO<sub>2</sub> was at least 10 € (Pohjola & Valsta 2007).

Ahtikoski et al. (2009) investigated whether the integration of carbon sequestration and biodiversity would financially encourage private forest owners to change their management behaviour at stand level. The financial assessments were based on to evaluation of the loss of net incomes, compared to business as usual (BAU) management, and they were calculated according to modified Faustmann rotation model. The data included 29 individual young (< 20 yrs) forest stands which were simulated for the full rotation by a stand simulator, MOTTI. The results indicated that integrating carbon sequestration and biodiversity conservation into the same management regime would be financially attractive – when comparing to BAU management – if the price for ton CO<sub>2</sub> is at least 5 € (Ahtikoski et al. 2009).

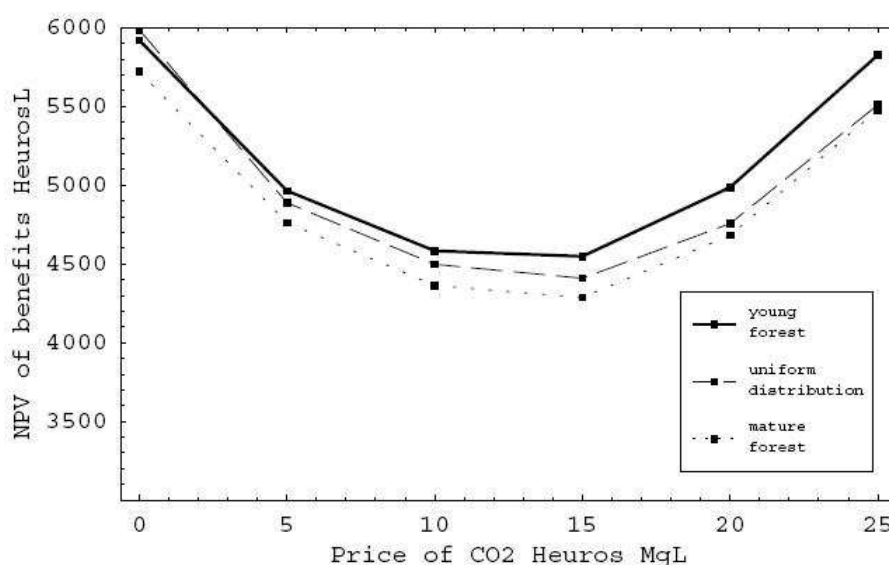
Cao et al. (2010) compared alternative carbon assessment methods for optimizing timber production and carbon sequestration in six Scots pine stands in southern Finland. Tree growth was forecasted by a process-based growth model PipeQual, and thinning regime for timber production and carbon sequestration (as a joint production) was formulated as a bound-constrained optimization problem. The bare land value, BLV was maximized by changing control variables in the optimization algorithm, which was based on direct and random search algorithms (a combination of a random search and Hooke & Jeeves' direct search). The objective was to maximize the bare land value including total returns from forest management comprising the net present value of both timber and carbon stock. Principally, the methodology resembles stand-level

optimization according to the Faustmann rotation model, but now with two simultaneous productions within the same management regime: timber and carbon sequestration. The analyses were restricted to stand level. The results showed that the joint production of timber and carbon sequestration in the same management regime clearly outperformed the sole production of timber, when the carbon price was at least 10.9 € ton CO<sub>2</sub>. However, the results were significantly sensitive to the applied carbon assessment method (stem carbon, biomass expansion factors or process-based model).

### 3.4.3.3 The Mediterranean region case

In the work of Goetz et al, 2007 in *Pinus sylvestris* in Catalonia they found that optimal management including timber and carbon sequestration objectives can reduce landowner incomes in different proportions, depending on the C market prices. It compares a baseline scenario of timber production with near 6000€/ha expected revenue in 200 years to a combination with Carbon sequestration, which decreases close to 4500€/ha for the same period when market price is between 10-15€/Mg C. See table 3. Pastor et al. 2006 find similar results in an specific forest site in western Catalonia with the same species.

**Table 3: Net present value of the forest management over 200 years as a function of the CO<sub>2</sub> price for different initial distributions of the forest (Goetz et al, 2007)**



Diaz-Balteiro et al, (2003) compares a status quo forest management in *Pinus sylvestris* in Central Spain with eight alternative paths addressed to carbon sequestration found as best-compromises or satisfying solutions for lexicographic Goal Programming models.



They found that opportunity costs for these improvements entail a reduction of around 11% of net present value and an increase of around 24% in the total carbon balance.

### 3.4.3.4 Developing country case

#### → Multi product cost function

Several studies have looked at public good provision costs in formal multiple product modelling frameworks, though not specifically using cost functions. Case studies in the Western and Eastern Brazilian Amazon employed mathematical programming to optimize farm-household consumption objective functions (Börner et al., 2007b; Carpentier et al., 2002). Both models were used to estimate provision costs of carbon sequestration and reduced emissions from deforestation tracking on farm plant species diversity. Provision costs were found to be generally higher in the Eastern Amazon case study, mainly due to higher returns to agricultural land uses and lower biomass density in predominant secondary forests.

All studies cited above allow for either direct or indirect derivation of marginal public good provision costs. Yet, not all studies do report marginal cost estimates.

**Table 4: Provision cost studies and methods for the derivation of marginal costs**

Source	Derivation of marginal public good provision costs
Börner and Wunder 2008 Börner et al. 2010 Nepstad et al. 2007	Indirect derivation from RED supply curves, by calculating incremental per unit costs.
Carpentier et al. 2002 Börner et al. 2007 Klemick in press	Direct derivation from dual model solution (mathematical programming) or by calculating revenue elasticities from production function coefficients (econometric models).

#### → Industrial and non-industrial forest owners

Börner et al. (2007a) analyze the effects of risk aversion on land use decisions and technology choice in the Eastern Brazilian Amazon in a farm-household modelling framework that considers non-separability of production and consumption decisions. Farm-households were, however, not sufficiently subsistence-oriented for non-separability to significantly affect the provision costs of public goods. Risk aversion, on the one hand, resulted in overspecialization in labour extensive slash-and-burn agriculture thus potentially increasing pressure on secondary forests and thus provision costs of forest-based positive environmental externalities. Aversion to production risks,

however, also tended to reduce the operational scale of slash-and-burn activities thus partially neutralizing the effect of increasing externality provision costs.

### **3.4.4 Water and other externalities**

#### **3.4.4.1 Atlantic urbanised case**

With a focus on groundwater contamination, the optimal decision of converting an area to Christmas greenery (and using fertilizers and pesticides) now or later has been investigated (Abildtrup and Strange, 1999). They find that the conventional NPV approach may not be optimal under uncertainty of future economic returns and if contamination is irreversible. In this case, when the decision can be postponed, an approach which includes the option value leads to a better decision.

More simplified is the opportunity cost analysis undertaken by Thorsen and Hedegaard (2003), where the effects of various forest management actions on groundwater recharge and quality is related to the likely range of opportunity costs, in terms of loss of NPV of production. The resulting cost ranges are compared to costs of alternative measures for the water provision sector, e.g. the extension of pipes or the movement of wells.

#### **3.4.4.2 Boreal region case**

There are elegant, recent studies dealing with joint production associated with forest landscapes (e.g., Zhou 2007, Olschewski & Benitez 2010) as well as single forest stands (e.g. Pohjola & Valsta 2007, Miina et al. 2010, Cao et al. 2010). Generally these studies deal with two simultaneous production of which timber production is usually the other one (Pohjola & Valsta 2007, Zhou 2007, Miina et al. 2010, Olschewski & Benitez 2010, Cao et al. 2010).

#### **3.4.4.3 Mountainous region case**

→ Technical approaches

Amongst environmental externalities, water cycle regulation and soil conservation play a primary role that cannot be subordinated to timber production (Notaro et al., 2008).

→ Producers/owners' preferences

Not many works have been published related to the case-study area describing the forest-owners' motivations in terms of forest management orientation preferences. This, despite as much as 67% of forestland in Italy belongs to private, usually small-scale, owners. A recent research has been published by Canton and Pettenella (2010), referring to a mountain area in the Veneto Region (case-study area for Newforex). Owners' motivations for forest management have been empirically identified by means

of structured interviews to a statistically representative sample of local forest holders. The paper presents different classifications of family forest owners based on a cluster analysis, which has led to the identification of three owners types with different motivations: one characterized by “Intangible Values”, another one of “multi-objective” owners and a third one of “Un-interested” owners, showing different socio-demographic features, various management, aims and information-seeking behaviour. Main results of this work report that forests are much more important for their intangible values and firewood self-consumption than for timber selling or other financial benefits.

#### → Other methods

A comprehensive assessment of forest-related externality values in Southern Europe has been published by Merlo and Croitoru in 2005. This book draws on a wide range of methods to assess the different components of Total Economic Values of Mediterranean Forests, amongst which cost-based methods. These have been used, for example, for estimating the value of the soil erosion function performed by forests based on replacement costs to meet for dredging soil accumulated downstream of the watershed (Croitoru *et al.*, 2005). In the same volume, the ‘defensive expenditure method’ has been used, for example, for the evaluation of some economic, social and environmental interests of French forests (Montagné *et al.*, 2005), like for example forest fires prevention and control, and defence costs along mountains and coasts.

In a recent article Gios and Goio (2008) have stressed the need of developing a system for forest accounting adequately integrating the benefits of non-traded goods and services. Extending traditional accounting in order to cater for ‘environmental green accounting’ has also been advocated by Merlo and Defrancesco (1999), who have applied a green accounting methodology to the Cansiglio area (i.e. one of our two case-studies). In this paper, they have estimated the values of some recreational/environmental services produced by the public forest owner in Cansiglio on the basis of the budget allocated for maintenance of: landscape, road and soil erosion prevention works, buildings used for touristic purposes and forest area in the ‘protection’ category.

In the paper quoted before, Gios and Goio (2008) have attempted at estimating, on a more local scale than Merlo and Croitoru (i.e. referring to the forests in Trentino, one Italian Region neighbouring Veneto), the value of the soil protection and water regulation function. This has been calculated with reference to substitute costs methods, by making reference to the cost of planting and maintaining a meadow (whose costs and soil protection and water regulation functions are known) in efficient conditions, as a replacement for the forest. Always focusing on the same externality – i.e. soil protection and water regulation, which is crucial in Italian Alpine forestry – Pettenella *et al.* (2004) propose to use either the ‘production or replacement cost method’, i.e. the costs for

producing and managing a forest directly for the specific purpose of regulating water regimes. According to Pettenella *et al.* (2004), an alternative way to estimate such an externality could be based on the estimate of the marginal costs met by the forest landowner to re-orient forest management towards a more effective water regulation. In this case, the costs have been estimated ranging from 5 to 22 € ha<sup>-1</sup> year<sup>-1</sup>; cost variability is mostly linked to the adoption of more or less severe forest management standards. Estimation of wastewater purification services carried out by forest filter areas has also been attempted by Mezzalana *et al.* (2008), who have used an opportunity cost approach based on the most profitable alternative crop in the area, i.e. maize.

Notaro *et al.* (2008) have also provided some estimates of the protection function of Alpine forests based on 'the estimated costs of the building, amortisation and upkeep of naturalistic engineering works designed to substitute this function'. This evaluation exercise has identified an annual value of the soil erosion protection function of 139.4 € ha<sup>-1</sup> of forest.

Tassone *et al.* (2004 and 2008) have identified private costs and benefits of plantation forests set through EU afforestation measures in Calabria, a Southern Italian Region; wood volume data, timber prices, afforestation costs, maintenance costs, opportunity costs of land, (i.e. farmers' loss of income as a consequence of the afforestation of agricultural land), harvesting costs have been estimated. These data have been used to determine the optimal forest rotation by using Faustman's formula.

A set of data aiming at assessing profitability of forest investments based on detailed accounting of forest landowners costs and benefits of forest management and related changes induced by the investments, has been produced by Gatto and Merlo and published within the MEDMONT project (Campos, 2004). The following table is presenting some of the most interesting result of this project.

**FOREST PRADUCCHIO-SALACÈ IN COMELICO**  
**SOCIAL PRODUCTION ACCOUNT AND NET OPERATING MARGIN**  
 (€/ha, year 2002)

CLASS*	Timber	Grazing	Hunting	Self-consumption	Mushrooms	Carbon	Recreation	Conservation	Infraestructure	Total
1. TOTAL PRODUCTION (TP)	198.9		17.0	15.2	25.0		11.8	23.6	0.8	292.3
1.1 INTERMEDIATE PRODUCTION (IP)										
1.1.1 Intermediate raw materials (IRM)										
1.1.2 Intermediate services (IS)										
1.2 FINAL PRODUCTION (FP)	198.9		17.0	15.2	25.0		11.8	23.6	0.8	292.3
1.2.1 Gross internal fixed investment (GIO)									0.8	0.8
1.2.2 Final sales (SFO)	138.1		17.0		25.0					180.1
1.2.3 Final stock (FSO)	60.8									60.8
1.2.4 Other final productions (OFO)				15.2			11.8	23.6		50.7
2. TOTAL COST (TC)	193.2				0.2		0.2		0.8	194.4
2.1 INTERMEDIATE CONSUMPTION (IC)	130.9								0.4	131.3
2.1.1 Raw materials (RM)	16.2								0.2	16.4
2.1.1.1 Own raw materials (ORM)										
2.1.1.2 External raw materials (ERM)	16.2									16.2
2.1.1.3 Government raw materials (GIRM)										
2.1.2 Services (SS)	18.1								0.2	18.3
2.1.2.1 Intermediate services (ISS)										
2.1.2.2 External services (EIS)	18.1									18.1
2.1.2.3 Government services (GIS)										
2.1.3 Production in progress used (PPu)	96.7									96.7
2.2 LABOUR (LC)	61.9								0.4	62.3
2.2.1 Employee (LE)	61.9								0.4	62.3
2.2.2 Self-employed (LSE)										
2.2.2 Government labour cost (GLC)										
2.3 FIXED CAPITAL CONSUMPTION (FCC)	0.4				0.2		0.2			0.8
NET OPERATING MARGIN (NOM = TP - TC)	5.6		17.0	15.2	24.8		11.6	23.6		97.9

\* 0.0 means a positive value lower than 0.05.

Source: Own elaboration.

Source: Campos, 2004

Table I.3

**FOREST PRADUCCHIO-SALACÈ IN COMELICO**  
**SELECTED ANNUAL FOREST STEADY STATE INDICATORS**  
 (€/ha, year 2002)

Indicator*	Private				Social		
	Commercial	Environmental	Total	(Factor cost) d=b+c	Commercial	Environmental	Total
	Market prices a	Factor cost <sup>1</sup> b	c		e	f	g=e+f
1. Labour costs (1.1+1.2)	62.3	62.3		62.3	62.3		62.3
1.1 Private							
1.2 Government							
2. Net operating margin (surplus)	5.6	- 6.4	15.2	8.9	47.4	50.5	97.9
3. Operating subsidies net of taxes on products		- 12.0		- 12.0			
4. Net value added (1+2)	67.9	55.9	15.2	71.1	109.7	50.5	160.2
5. Capital revaluation (5.1+5.2)	35.5	35.5		35.5	35.3	- 0.2	35.1
5.1 Production in progress current revaluation	35.9	35.9		35.9	35.9		35.9
5.2 Fixed capital current revaluation	- 0.4	- 0.4		- 0.4	- 0.6	- 0.2	- 0.8
6. Fixed capital consumption	0.4	0.4			0.6	0.2	0.8
7. Capital gains (5+6)	35.9	35.9		35.9	35.9		35.9
8. Capital income (2+7)	41.5	29.5	15.2	44.8	83.3	50.5	133.8
9. Total sustainable income (1+2+7)	103.8	91.8	15.2	107.0	145.6	50.5	196.1
10. Immobilised capital <sup>2</sup>	1,482.4	1,482.4	304.8	1,787.1	3,572.8	2,067.0	5,639.8
11. Operating profitability rate (%) (3/10)	0.4	- 0.4	5.0	0.5	1.3	2.4	1.7
12. Capital gain rate (%) (7/10)	2.4	2.4		2.0	1.0		0.6
13. Partial profitability rate (%) (11+12)	2.8	2.0	5.0	2.5	2.3	2.4	2.4
14. Total profitability rate (%) (8/IMC) <sup>3</sup>	2.3	1.7	0.9	2.5	1.5	0.9	2.4

<sup>1</sup> The factor cost values include the operating subsidies net of taxes on products.

<sup>2</sup> The private immobilised capital at factor cost does not include the net operating subsidies in its estimation.

<sup>3</sup> Estimated over the total immobilised capital (IMC).

\* 0.0 means a positive value lower than 0.05.

Source: *Own elaboration.*

Source: Campos, 2004

Ciancio *et al.* (2007) have proposed a methodology for estimating environmental damages due to forest fires. Amongst the different approaches, one is based on reconstruction (restoration) costs, on the assumption that an asset is worth at least what it costs originally. The approach is based on the following formula:

$$FD_{RC} = \text{area} * DL * RC$$

where:

$FD_{RC}$  forest function damage (€);

area = area burned by the fire (ha);

DL = level of damage caused by the fire

RC = reconstruction cost (€/ha).

The approach has been tested in the Longobucco mountain forest area, in Calabria Region.

#### 3.4.4.4 Developing country case

→ Multiproduct cost function

Klemick (in press) used a farm-household production function in a spatial econometric model to estimate the value of local hydrological externalities of secondary forest fallows. A surprising result was that local hydrological services from adjacent forest areas seemed at least as important for smallholder productivity as the direct soil productivity enhancing services of fallows in slash-and-burn systems.

### 3.5 *A summarizing table of estimated costs for the provision of forest externalities*

#### 3.5.1 Boreal region case

**Table 5: Recent studies (best available knowledge) on the costs of providing different environmental services, i.e. forest externalities in Finland. Column “Main results” include reported estimated costs of empirical papers reviewed here.**



Forest Externality	Article	focus/scope	Cost types included	Data (location, inter alia)	Main results
Biodiversity	Juutinen et al. 2008	to estimate whether it would be more cost-efficient ( <i>for the government</i> ) to buy than lease forest stands possessing valuable environmental characteristics on privately owned forests in producing biodiversity services	<ul style="list-style-type: none"> <li>• opportunity costs</li> <li>• transaction costs</li> <li>• administration costs (imple-mentation costs)</li> </ul>	<ul style="list-style-type: none"> <li>• 59 individual stands derived from the TNV (Trading in Natural Values) database</li> <li>• Stands were located in SW Finland</li> </ul>	<ul style="list-style-type: none"> <li>• direct costs of land purchases were lower than the direct costs of land leasing, when interest rate in less than 3%</li> <li>• with interest rates higher than 4% land leasing was more cost-efficient</li> </ul>
Biodiversity	Ahtikoski et al. 2007 <sup>a)</sup>	to assess which type of conservation (permanent, temporary with different time spans) would result in the lowest loss in timber income when providing biodiversity services [ <i>private forest owner's viewpoint</i> ]	<ul style="list-style-type: none"> <li>• opportunity costs</li> </ul>	<ul style="list-style-type: none"> <li>• one stand</li> <li>• located in southern Finland (Note: results were solely based on stand-level simulations)</li> </ul>	<ul style="list-style-type: none"> <li>• 20-yr temporary conservation resulted in the lowest timber income loss, varying between 1 663 to 5 489 €/ha, (discount rates 2 or 4%, respectively)</li> <li>• with respect to biodiversity index the permanent conservation was outstanding</li> </ul>
Biodiversity	Juutinen & Ollikainen 2010	to analyze the performance of competitive bidding (by using a simulated biodiversity bidding model), and to compare the results with actual bids in the Trading in Natural Values program [ <i>government's viewpoint</i> ] <sup>b)</sup>	<ul style="list-style-type: none"> <li>• opportunity costs<sup>b)</sup></li> </ul>	<ul style="list-style-type: none"> <li>• 400 individual stands representing different age classes in southern Finland</li> <li>• All relevant soil types (from dryish to herb-rich) are presented</li> </ul>	<ul style="list-style-type: none"> <li>• as high as 25% decrease in rental payment (to private forest owners) would not necessary mean a drastic drop in biodiversity score (i.e. the "quality" of key ecological forest habitats)</li> <li>• results suggest a strong argument favouring voluntary approaches to biodiversity conservation in Finland</li> </ul>
Biodiversity	Siikamäki & Layton 2007	to develop site-level estimates of the opportunity cost of protecting biodiversity hotspots [ <i>private forest owners' viewpoint</i> ]	<ul style="list-style-type: none"> <li>• opportunity cost</li> </ul>	<ul style="list-style-type: none"> <li>• a survey with 1 129 respondents, covering whole Finland (province-specific quotas, 10 provinces included) [NOTE: beta-binomial model applied in predicting the potential enrollment]</li> </ul>	<ul style="list-style-type: none"> <li>• results suggest that a fairly simple incentive payment program (IPP) could achieve conservation targets with a cost-effective manner</li> <li>• IPPs' market-like policy mechanism would help drastically to prioritize the sties to be conserved</li> </ul>

Forest Externality	Article	focus/scope	Cost types included	Data (location, inter alia)	Main results
Biodiversity	Horne, P. 2006	To evaluate the amount of compensation needed to keep the forest owners at least as well off as before the conservation contract [ <i>private forest owner's viewpoint</i> ]	<ul style="list-style-type: none"> <li>• opportunity cost of biodiversity conservation (obtained through choice experiment approach)</li> </ul>	<ul style="list-style-type: none"> <li>• sample size of 2 952, and the final response rate being 42% resulting in a 12 39 respondents</li> <li>• whole country, excl. province of Ahvenanmaa</li> </ul>	<ul style="list-style-type: none"> <li>• the trade-offs between compensation and the terms of voluntary conservation contracts revealed that average welfare impact would be 62 €/yr/hectare to compensate the forest owners</li> </ul>
Carbon sequestration	Pohjola & Valsta 2007	to determine the optimal combination of thinnings and rotation period for joint production of timber and carbon sequestration with alternative carbon prices [ <i>private forest owners' viewpoint</i> ]	<ul style="list-style-type: none"> <li>• opportunity cost (not directly assessed, but can be derived from the results indirectly)</li> </ul>	<ul style="list-style-type: none"> <li>• 10 Scots pine and 7 Norway spruce stands, representing poor to nutrient-normal sites (Scots pine) and normal to nutrient-rich sites (Norway spruce)</li> <li>• Located in southern and central Finland</li> </ul>	<ul style="list-style-type: none"> <li>• the carbon tax/subsidy programme delayed both clearcutting and thinnings with Scots pine, but it affected mainly the rotation length with Norway spruce</li> <li>• including carbon sequestration into objective function increased the incomes to forest owner considerably when comparing the incomes of solely timber production (subsidy level either 10 or 20 € / ton CO<sub>2</sub>)</li> </ul>
Carbon sequestration	Ahtikoski et al. 2009	to evaluate whether the integration of carbon sequestration and biodiversity would financially encourage private forest owners to change their behaviour with respect to forest management [ <i>private forest owner's viewpoint</i> ]	<ul style="list-style-type: none"> <li>• opportunity costs</li> <li>• (indirect transaction costs)</li> </ul>	<ul style="list-style-type: none"> <li>• 29 individual forest stands in southern Finland</li> <li>• stands represent soil types from nutrient-poor to nutrient rich types</li> </ul>	<ul style="list-style-type: none"> <li>• results indicate that integrating carbon sequestration and biodiversity into the same management regime would be financially attractive (when comparing to BAU managementd) ), if the price for CO<sub>2</sub> varies between ca. 5 and 12 €/ton CO<sub>2</sub> (discount rates 3, 4 or 5%)</li> <li>• results were quite robust with respect to dominant tree species (either spruce or pine) as well as site type</li> </ul>

Forest Externality	Article	focus/scope	Cost included	types	Data (location, inter alia)	Main results
Recreation	Ahtikoski et al. 2010	To assess local net impacts of three alternative land-use scenarios, in which the level of integration between nature-based tourism (NBT) and traditional forestry (BAU) is varied	<ul style="list-style-type: none"> <li>• opportunity costs</li> <li>• transaction costs</li> <li>• social costs</li> </ul> [NOTE: also employment impacts evaluated]		<ul style="list-style-type: none"> <li>• study area located within the Kätkä-Aakenus mountain area in Fell Lapland, northern Finland</li> <li>• total of 5600 hectares of forest land</li> </ul>	<ul style="list-style-type: none"> <li>• results support the idea of an eligible integration between NBT and forestry, which takes into account scenic qualities of forested landscapes by restricting traditional management practices</li> </ul>

a) In Finnish without an English summary, b) although the assessments were made from the government's viewpoint, the results also reflect the opportunity costs relevant for a private forest owner when providing environmental benefit (biodiversity services), c) carbon uptake is subsidized and carbon release is taxed, i.e. subsidy on sequestration and tax on release of carbon, d) BAU management represents business as usual management which is based on the prevailing silvicultural recommendations in Finland (Anon. 2006)

### 3.5.2 Central European region

**Table 6: Recent studies (best available knowledge) on the costs of providing different environmental services, i.e. forest externalities in Poland. Column “Main results” include reported estimated costs of empirical papers reviewed here.**

Forest Externality	Article	focus/scope	Cost types included	Data (location, inter alia)	Main results
Biodiversity	Czajkowski et al. 2008	The paper attempts to improve current understanding of the economic value of biodiversity. Interestingly, respondents valued passive protection regimes resulting in preservation of natural ecological processes. In addition, the respondents seemed to be concerned with the means, and not only the results of protection programmes.	• opportunity costs of biodiversity conservation	• Białowieża primeval forest	19.82 Eur/household/year for complex conservation program composed of: <ul style="list-style-type: none"> <li>• increasing area of passive protection to 60% of Białowieża Forest,</li> <li>• maintaining and expanding current population of endangered species.</li> </ul>
Recreation	Bartczak et al. 2008	This paper reports the findings of the first comprehensive, national-level study in any Central- Eastern European country estimating annual and per trip forest recreation values in Poland using the Travel Cost (TC) and Contingent Valuation (CV) methods. Two in-person interview surveys of forest recreation behaviour were carried out.	• opportunity costs	• This study was administered onsite in ten representative forest areas. Total sample size 1000 respondents.	• Results show that forest recreation is highly valued in Poland, at Euros 0.64– 6.93 per trip per person, depending on the valuation method. Both trip frequency and per trip values are higher than the average in Western Europe, despite a lower income level.
Recreation	Giergiczny (2009)	Zonal travel cost method (ZTCM) is used to measure the recreational economic benefits from visitation in the Białowieża National Park.	• opportunity costs	• on-site, 450 visitors	• Visitors are estimated to have received a total of 11.5 million zł (2002) in net benefits from their recreational experience, above the cost of travelling to the wilderness area, or 105 zł per individual visit.

## 4. A FRAMEWORK FOR ASSESSING COST OF EXTERNALITY PROVISION: SCENARIOS, EXPECTED IMPACTS AND COST DRIVERS

In order to assess the cost of provision of forest externalities, we develop a simple conceptual framework of non-industrial forest owners. Cost assessment requires three elements: the business-as-usual (BAU) case, the forest management scenarios, and the costs drivers.

Obviously, we opt for a low specification form, in order to keep as much flexibility as possible, in order to be able to integrate all the case studies and their specificities. It will be then possible to adapt the model for a particular case study if this is relevant. The advantage is that we have here a general form that may fit with all the CS.

### 4.1 *Status-quo scenario or 'Business As Usual'*

The BAU scenario describes what would be the outcome in terms of forest management, timber production and externality provision if no policy is implemented. It is necessary to compare with the case in which an additional amount of externalities is provided.

#### 4.1.1 Theoretical framework

We consider a representative forest owner, maximizing its utility, which takes the form of a weighted sum of revenues and externalities from his privately owned forest<sup>3</sup>:

$$U(M) = \alpha U_I(I(M)) + (1 - \alpha) U_A(A(M)) \quad (1)$$

$\alpha$  is the weight given by the forest owner to income (and thus to consumption), while  $(1 - \alpha)$  is the weight given to forest externalities (or environmental preferences):  $\alpha = 1$  refers to a profit-maximizing industrial forest owner;  $\alpha = 0$  refers to a forest owner not considering potential income that could be get from his forest.  $U_I$  is the utility of income or consumption  $I(M)$ , and  $U_A$  is the private utility that the forest owner gets from the externalities  $A(M)$  his forest provides. Both functions have standard properties. In a

<sup>3</sup>Note that we consider a simplified static model, while forest management usually implies dynamic profit maximization (Faustmann and others). The utility function may thus be considered as the current utility that may be derived from dynamic maximization. Indeed, we do not consider explicitly utility maximization, but only compare two situations in which utility maximization is already done.

simplified version, we may assume that:  $U_I = I(M)$  and  $U_A = A(M)$ . In this case,  $\alpha$  is the only indicator of preferences that is to be assessed.

The forest owner's income  $I(M)$  is composed of current forest profit  $\Pi(M)$  and outside income  $OI$ .  $M$  is a vector of forest management practices (rotation length, harvest intensity, species choice, labor used, implementation of recreational facilities...) :  $M = (M_1, \dots, M_J)$ . The forest profit function may be written as:  $\Pi(M) = Y(M) - c(M)$ , with  $Y(M)$  the income of sold timber and other marketed goods and services, and  $c(M)$  the forest management costs.

$A(M)$  is a vector of forest externalities (carbon sequestration, biodiversity, recreation, water quality and quantity...) :  $A(M) = (A_1(M), \dots, A_I(M))$ .

The forest owner chooses his forest management practices to maximize his utility, which gives the vector of optimal forest management practices  $M^*$ , implying profit  $\Pi^* = \Pi(M^*)$  and externalities  $A^* = A(M^*)$ .

#### 4.1.2 BAU in the CSPs

##### 4.1.2.1 Atlantic case

Leaving trees for natural decay, when performing the main harvest is today mandatory in all certified forests including the state forests. At present, approximately 46% of the Danish forest area is certified (PEFC, 2010). This change has occurred relatively recent, and while deadwood amounts have been increasing there is still little dead wood in the forests today and ample scope for enhancements with this type of forest management change.

Today it is assessed that most of the beech forest area in the country is regenerated using natural regeneration since this is economically most profitable (Vedel et al., 2010).

1.6% of the forest area in the country is set aside as untouched forest areas (Ejrnæs, 2009).

The current tree species distribution in Denmark constitutes 63% conifers and 37% broadleaves (Larsen and Johannsen, 2002).

Rune (2001) states that during the 19th century, the proportion of wet areas in forests in the eastern part of Denmark has decreased from approximately 20% to 3.5%.

On publicly owned forest areas (26%) the public has access on foot to all areas at all times. Picking berries etc. is also permitted. The public is also allowed to bike on all

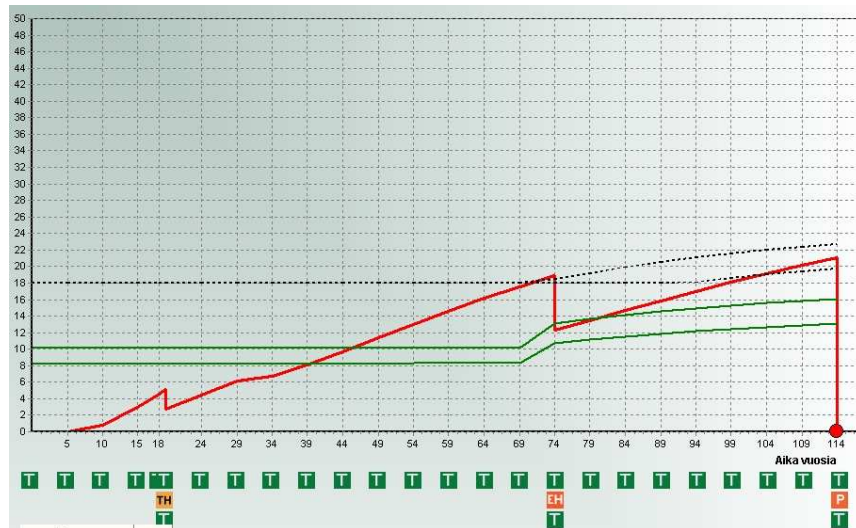
forests roads and small paths in the forest but motorized vehicles are forbidden everywhere. In designated areas people are free to spend the night, light a camp fire etc. On privately owned forest areas, the public has access on foot and bike to all forest roads and paths from 6 am to sunset but access to the forest floor is forbidden. If the forest is smaller than 5 ha the owner may restrict public access.

#### **4.1.2.2 Boreal region case**

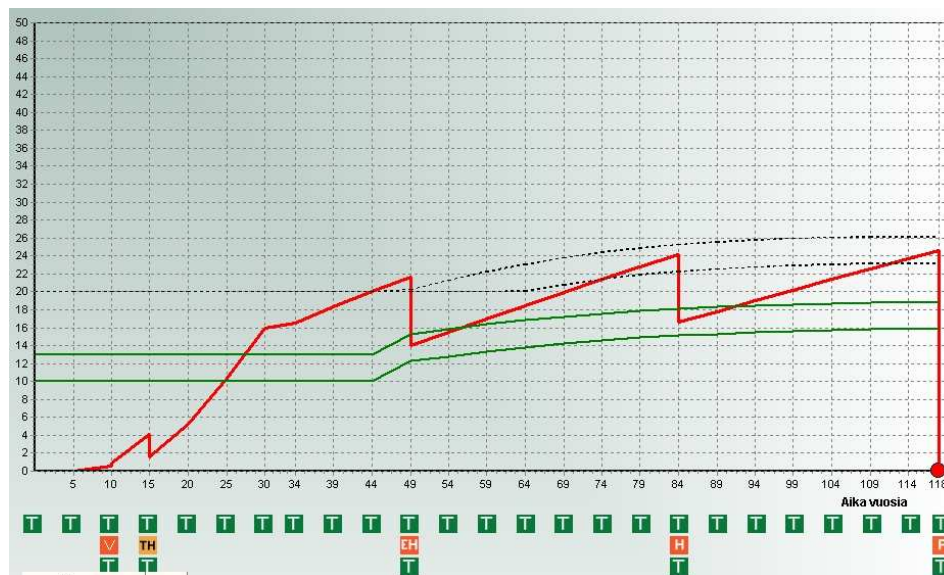
Finland is the most forested country in Europe with large amounts of rural and peripheral areas with decreasing amounts of job opportunities and population numbers. App. 20.1 million hectares are suitable for active forestry, and the average holding size is about 24 hectares (totally 920000 forest owners, 440000 holdings). Timber production has long been the key management objective for large share of forests in Finland supplying timber for forest industry. Annual roundwood removal has varied between 54 and 65 million cubic meters from which app. 80% comes from private forests. The total growing stock is about 2200 million cubic meters of which Scots pine 50 %, Norway spruce 30 % and 20% broadleaves (mainly birch). Finnish forests provide job opportunities to about 83000 people in Finland, and the value added of forest sector was in 2008 as much as 8.2 billion € (Anonymous 2009).

The current BAU in the Finnish case is even-aged forest management for timber production which focuses mainly on producing pulpwood and timber. The BAU follows sustainable principles emphasizing the fact that total increment in Finnish forests always outweighs the drain in 5-year periods. In Figures 3 and 4 BAU management is illustrated at stand level so that silvicultural measures, actions (e.g. stand establishment, tending of a sapling stand, thinnings and final cut) are depicted for two typical site types and tree species in our study region, Ruka area (NE Finland, average temperature sum 850 d.d.). Of course, actions depend on the site type, tree species and geographic location, but in general the BAU management in Finnish forests is quite straight-forward since the actions to be taken are reported for each case in “Recommendations for good silviculture” (Anonymous 2006).





**Figure 3: A BAU management for Scots pine, dryish site type in Ruka area (NE Finland).** Red curve presents the stand development as a function of basal area ( $\text{m}^2/\text{ha}$ : vertical axis), and stand age is on a horizontal axis. For instance, tending of a sapling stand (“TH”) takes place at stand age 19, and first commercial thinning (“EH”) at the age of 74. The rotation period is 114 years. The mean annual increment (MAI) according to the BAU management is app.  $1.8 \text{ m}^3/\text{ha}$  (of which 0.5 sawlogs).



**Figure 4: A BAU management for Norway spruce, fertile site type in Ruka area (NE Finland).** For instance, tending of a sapling stand (“TH”) takes place at stand age 15, and first commercial thinning (“EH”) at the age of 49. Second commercial thinning takes place at the age of 84 years. The rotation period is 118 years. MAI according to BAU management is here  $2.5 \text{ m}^3/\text{ha}$  (of which 1.3 sawlogs).

The specific feature related to the BAU management in Finland is that in most cases the rotation period ends up with the clear cut, or in some cases final cut with a few retention trees (<20). In general this behaviour contradicts continuous cover forestry in

which clear cuts are prohibited. Another feature related to BAU management in Finland is the fact that stand establishment is in most cases conducted through artificial regeneration (either by planting or by direct sowing), not by natural regeneration.

#### 4.1.2.3 The Mediterranean region case

Our BAU scenario is the absence of management. Such lack of management in *Pinus halepensis* forests in Catalonia entails high density stands, small tree diameters, slow tree growth, lower timber quality and accumulation of excessive biomass. Such development often results in a limited ability of Carbon sequestration and a decrease of diversity at stand level. The resulting forest structure decreases wildfire resistance. Another consequence of abandonment is the loss of heterogeneity and the mosaic structure. Accessibility and visibility across the forest is affected by the forest structural change, which might lead to a lower attractiveness of the landscape, and consequently a decreased recreation demand jointly with lower habitat diversity at landscape level.

In terms of timber, current silvicultural treatments in *Pinus halepensis* forests have as unique market the particleboard or pulpwood. Alternative uses and related prices are exposed in table 7:

**Table 7 – Requirements and timber prices for *Pinus halepensis* in Catalonia (Mundet, 2009 and Consorci Forestal de Catalunya, 2010)**

	Diameter at the tip of the tree	Other requirements	Prices (2009)	Use
Pulpwood	$\Phi < 14\text{cm}$	none	27.65 €/tn	Particle board or pulp (outside Catalonia)
Sawing wood, quality 1	$\Phi = 14\text{-}20\text{cm}$	Certain trunk straightness	36 €/tn	Pallets
Sawing wood, quality 2	$\Phi > 20\text{cm}$	Straightness in trunk, no knots	39 €/tn	Fruit boxes or wooden coils for electric cables

#### 4.1.2.4 Mountainous region case

Italian forests can be described as a multifunctional semi-natural resources managed according to the principles of ‘close-to-nature’ silviculture. Due to the high variability of ecological and climatic conditions there are several forest typologies that follow different management and silvicultural practices. Generally, in relation to forest management systems, two main categories are identified: coppice with standards and high forest.

Coppice forests are usually managed for fuelwood production under relatively short rotation periods (12-25 years). Public regulations are frequently defining quite strict limitations to coppice forest harvesting to enhance soil protection against erosion (e.g:

minimum rotation period, minimum number of standards, maximum clear-cut areas, etc.). Similarly high forests in Alpine Region are managed with the target of protecting soil stability and other public goods. These forests are generally mixed uneven-aged or even-aged forests, while not rare are irregular ones. The silvicultural system is based on the selection of single or small groups of trees on areas of not more than 1000-2000 m<sup>2</sup>. This practice allows a continuous soil cover, the natural regeneration, and a set of other outputs of public goods like water cycle regulation, landscape conservation and biodiversity maintenance at different level ( $\alpha$ ,  $\beta$ ,  $\gamma$ ). In some area where threatened wildlife species live, the forest is set aside or cut far below the annual forest increment. In few cases, forests - like for example beech highforests in Cansiglio - are monospecific and even-aged; in this case the silvicultural treatment is the shelterwood system type, based again on natural regeneration and following the natural evolution of the forest ecosystem.

The overall forest output is low in terms of timber profitability but very valuable for the externalities produced. For instance, wild mushroom collection occurs and in many cases Non-Timber-Forest-Products (NTFPs) harvesting is more profitable than timber production. For an increasing number of NTFPs specific regulations have been introduced to keep sustainable levels of harvesting, in the same time allowing the transformation of NTFPs from public to club or private goods.

Therefore, the BAU scenario is already one of a high level of production of externalities, where timber production can be considered sometimes even a by-product of a system oriented towards the maximization of a bunch of externalities, in which soil protection and erosion control predominate in slope areas and biodiversity and recreation are important for the other forests.

#### **4.1.2.5 Central european region**

The Białowieża Forest is the largest area of natural deciduous lowland forest in Europe. The Białowieża Forest is located in Poland (58 000 ha) and Belarus (67 000 ha). The whole Belarusian side of the Białowieża Forest has been protected as a national park since 1991.

The Białowieża Forest in Poland is currently under two different management strategies. Part of the forest (ca. 17%) lies within the Białowieża National Park (BNP) while the rest is managed by the State Forests National Forest Holding (LP). Half of the BNP is preserved as a strict nature reserve and has been approved as a Biosphere Reserve and the World Heritage Site in 1979. The Białowieża Forest has been protected in various ways for centuries. Currently the highest protection regime is implemented in the BNP, where the use of the forest is limited to scientific research and nature-based tourism.

The area within the Białowieża National Park is currently well protected, and no changes in protection regime are required there. It is possible, however, to consider other set of recreational access restrictions. In the rest of the Białowieża Forest (managed by LP) different forms of nature protection are present. The total protected area excluded from commercial logging in the part of the Białowieża Forest under the LP management is equal to 12 000 ha and is slightly larger than the area of the Białowieża National Park. This does not mean, however, that this area is strictly protected – tree felling is still possible there.

The entire area of the forest outside the BNP is managed by the National Forest Agency. More than 80% of this area, including numerous patches of old-growth stands and naturally regenerated 80-90 year-old stands, are subject to forest management involving: harvesting, replanting and pest control. In 2001-2009, 110-140 000 m<sup>3</sup> of timber were extracted every year.

In 2003 the Ministry of Environment lifted the ban on felling trees over 100 years old; this ban did not comprise naturally regenerated stands. It is also worth stressing that in spite of the ban there have been numerous cases of tree felling in old growth stands, usually these actions are justified by controlling Bark Beetle infestations. For example, old-growth spruce stands in reserves can be felled once they are infested by spruce bark beetles. In addition, the Ministry of Environment has limited the timber production in the Białowieża Forest to 48 000 m<sup>3</sup>, starting from 2011 (in 2010 the limit was set to 111 000 m<sup>3</sup>).

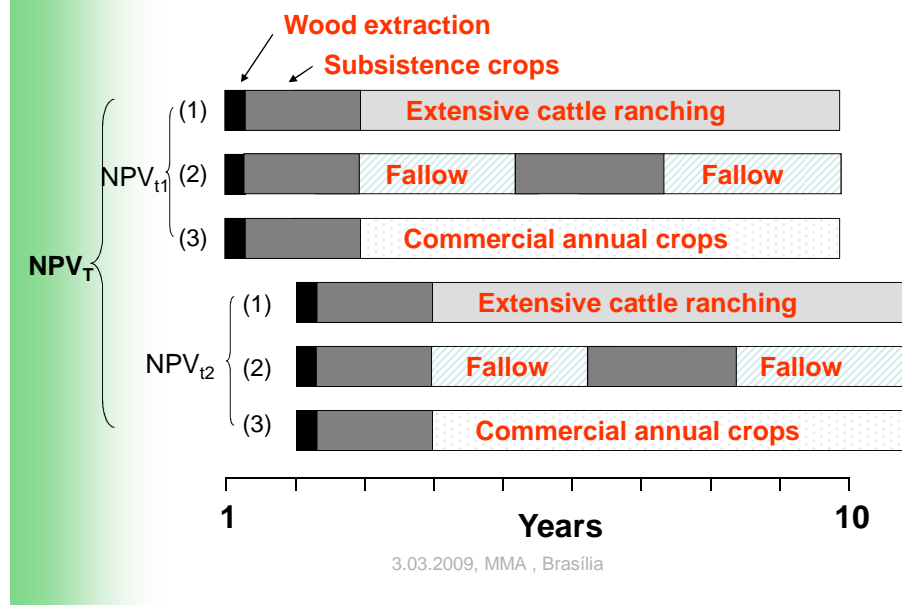
In recent years the Ministry of Environment have undertaken numerous actions to limit commercial use of the Białowieża Forest outside the BNP. Despite these actions, every year there are cases of extracting timber from valuable stands outside the BNP. According to biologists the best way of protecting the unique biodiversity of the Białowieża Forest is extending the BNP to entire area of the forest.

#### **4.1.2.6 Developing country case**

The typical business-as-usual land-clearing pattern in the Brazilian Amazon comprises deforestation cycles that start with selective extraction of valuable timber species, and are then followed by slash and burn/ mulch with a period of subsistence cropping (to take advantage of the nutrient-rich and pest-free soils after burning). Some lands go directly into various continuous years of pasture establishment, others continue an itinerant farming approach, while again other areas establish commercial annual or perennial cropping systems (see Fig 1). This also means that environmental service delivery is mostly defined along the lines of the forest conservation versus agricultural conversion dichotomy, rather than e.g. different timber management regimes. Efforts towards sustainable forest management do exist in the Brazilian Amazon, but the areas

being sustainably managed jointly for timber and environmental services (e.g. certified timber production areas) still remain very small.

**Fig 1. Amazon land-clearing trajectories**



## 4.2 Forest management scenarios: Key actions and expected impacts on forest externalities

Once the BAU scenario is defined, we need to know the key forest management practices that can be implemented in order to increase the provision of externality. Then, we have to assess which additional amount of externalities is to be provided by those changes in forest management.

### 4.2.1 Theoretical framework

Consider now that some policy (mandatory, voluntary) leads the forest owner to increase the provision of a key forest externality  $A_i$ ,  $i \in [1, I]$ . The key actions to be undertaken imply a change in forest management practices from  $M_j^*$  to  $M_j^{EX}$ ,  $j \in [1, J]$ . Alternatives in forest management encompass: managed vs non managed forests, rotations, species...

The amount of externality provision then increase from  $A_i^*$  to  $A_i^{EX}$ . The change in forest management implies changes in profit from timber production and in other forest externalities:  $\Pi^{EX} = \Pi(M^{EX})$  and  $A^{EX} = A(M^{EX})$ .

## 4.2.2 Key actions and expected impacts in the CSPs

### 4.2.2.1 Atlantic urbanised case

The key actions relevant here range from intensive management changes over small-scale management to various levels of protection. The management changes that will be considered here are all under the umbrella of near natural forestry. The management changes included here are grouped in low and high impact changes – except for “Changes in recreational options”. The low impact changes are: Selection of mature trees to be left to die, increased rotation age of broadleaved stands and increased use of low-impact and natural regeneration. The high impact management changes are setting aside forest areas for untouched forests, change in tree species from coniferous to broadleaves and reestablishment of wet areas.

Paillet et al. (2010) have made a meta-analysis of 49 studies regarding the difference in biodiversity levels between managed and unmanaged forests. They find that species richness is slightly higher in unmanaged forests and that this difference increased over time. Increasing the area of broadleaved trees has had a positive effect on biodiversity in coniferous areas (Patterson, 1993; Humphrey et al., 1998) and it also leads to greater diversity in fungal (Humphrey et al., 2000) lichen and invertebrate species (Humphrey et al., 1998). Quantitative effects of forest management changes on carbon stock have been assessed by Hyvönen et al. (2007).

In D2.1, the Atlantic case study section, the above mentioned forest management scenario actions are linked to relevant sources of information regarding possible assessment of the technical impact on mainly groundwater and biodiversity and to some extend carbon. Sources include Anthon et al. (2003), Raulund-Rasmussen and Hansen, 2003 and Jensen (1999). A recent large literature review (EFORWOOD report WP2.2, 2007) provides qualitative assessments of the impact of different forest management changes on biodiversity, but little information on possible quantitative impacts.

**Table 8: Direction of the impacts on forest externalities of some forest management actions. The Atlantic urbanised region case.**

Forest management scenario / change	Impact on biodiversity	Impact on recreation / nature-based tourism	Impact on watershed management	Impact on carbon sequestration
-------------------------------------	------------------------	---	--------------------------------	--------------------------------



<b>BAU: Mainly even-aged forest management for timber production, bioenergy, hunting, (0)</b>	Continued decrease in biodiversity, e.g. loss of species and more species being threatened	Same level of recreational access and quality	Continued loss of nutrients after regeneration cuttings and soil preparation.	In general neutral, but depends on the age structure of the whole forest area and the end use of harvested timber (life cycle impact of final products)
<b>Change from conifers to broadleaves</b>	Larger long run increase in biodiversity due to more native species linked to these forest types	In general increased quality of the recreational experience due to larger visibility in forests, and more ground floor herbs, shrubs and fungi	With natural regeneration, a complete stop for nutrient loss in most forests.	Can be the same or lower, depending on site index and species switch. Will also depend on life cycle impact of products.
<b>Leaving 5 trees per hectare</b>	A smaller increase in the medium run in biodiversity – from fungi and insect to species of birds and small mammals	Could be slightly enhanced (due to biodiversity experiences) as well as slightly decreased (due to possible neg. preferences for seeing decaying trees)	Little or no effect	Little or no effect
<b>Larger areas with untouched forests</b>	A larger increase in the medium to long run in biodiversity – from fungi and insect to species of birds and small mammals	Could be everything from much enhanced (due to biodiversity experiences) to much decreased (due to possible neg. preferences for seeing decaying trees and 'messy' new forest stands)	Reduce nutrient loss until in biochemical balance. May then not be able to retain incoming airborne N-flux from agriculture.	Positive as far as the short-term sequestration in the forest. Long run effect is minimal, and maybe even negative due to zero export to other uses.

#### 4.2.2.2 Boreal region case

The key actions taken in Finnish standing forests are primarily thinnings and final cuts (harvests), since through thinnings and final cuts we can control and include forest externalities into stand management regimes. By adjusting thinnings and harvests to contribute to the provision of forest externalities, we can significantly enhance the supply of forest externalities from our forests. The different scenarios for the boreal region case (Ruka area in NE Finland) would be:

- (0) BAU, even-aged forest management for timber production (based on prevailing silvicultural recommendations which emphasize timber production). Occasionally natural regeneration methods applied, the mainstream being artificial regeneration (either planting or direct sowing)



- (1) small-scale management for nature-based tourism (in which, e.g. the nearby environment along the trails for outdoor recreation are in restricted forest management within the buffer zone)
- (2) Continuous cover forestry for biodiversity and recreation (timber production through an uneven-age management regime with selective harvesting only, i.e. no clear cuts at all) Aesthetic and recreational functions of forests are emphasized as well as biodiversity aspects.
- (3) Scenario providing recreation infrastructure in private forests (services for nature-based tourism to be provided for visitors such as marked trails and other recreation infrastructure). Main emphasis on recreation services.

Altogether, four (0, 1, 2 and 3) scenarios of which three (1-3) present notable changes in providing forest externalities. The directions of the impacts on externalities are summarized in the following table.

**Table 8: Direction of the impacts on forest externalities. The Boreal region case.**

Forest management scenario / change	Impact on biodiversity	Impact on recreation / nature-based tourism	Impact on watershed management	Impact on carbon sequestration
<b>BAU:even-aged forest management for timber production (0)</b>	Decreased amount of biodiversity, i.e. biodiversity conservation level less than desired	Decreased quality of the recreation environment (clear cuts and soil reparation) Improved walkability and visibility in young stands	Increased leaching of nutrients after regeneration cuttings and soil preparation	In general neutral, but depends on the age structure of the whole forest area and the end use of harvested timber (life cycle analysis of final products)
<b>Small scale management for nature-based tourism (1)</b>	Generally positive impacts on biodiversity, but not a straight-forward impact	Positive impact to recreation environment	Positive impact on water quality as smaller areas are under intensive management	Depends on the time frame and end use of the harvested timber
<b>Continuous cover forestry for biodiversity and recreation (2)</b>	Possible positive impacts on biodiversity (depending e.g.on tree species groups,)	Positive impact to recreation environment. Less variation in the landscape in the long run	Positive impact on water quality as smaller areas are under intensive management	Depends of the time frame and end use of the harvested timber
<b>Scenario providing recreation infrastructure in private forests (3)</b>	Large recreational use may disturb wilderness species	Improved possibilities to use areas for recreation, large numbers of visitors disturb the wilderness	Minor effect on water quality	Minor effect on carbon sequestration.

---

	experience (purists).	
--	-----------------------	--

---

**References**

Anonymous 2006. Hyvän metsänhoidon suositukset. [Recommendations for good silviculture]. Helsinki, 100p.

Anonymous 2009. Statistical Yearbook of Forestry 2008. 450 p.

**4.2.2.3 The Mediterranean region case**

In this study four scenarios are proposed, ranging from high intensive management where the main goal would be the wood production, to low intense management practices that would rather focus on other forest goods and services. (Further information available in D.2.1-chapter 4)

The Intensive forest management scenario focuses in improving the timber quantity and quality. This is the current itinerary recommendations for private forests and the basis of the subsidies for Sustainable Forest Management in the region. It will cover a pre-commercial thinning when the forest ages 25 years, another thinning around 50 years and a final harvesting when the stand get the 80 years.

The second scenario proposes a moderate-intensity forest management addressed to achieve an uneven-aged stand. It constitutes a common practice in public forests in Catalonia, given the less timber orientation but more benefits for externalities production. This approach includes more often interventions (around every 10 years) looking for creating “group openings”, based on group selection treatments. Such system will enhance regeneration, and facilitate the presence of new plant species.

The last scenario promotes a so-called close-to-nature management, in which timber objective is completely substituted by the goals of creating a mixed, uneven stand and improve other externalities. It differs from the former scenario in the technique applied, given that the focus here is in the single tree selection -instead of the group selection-. Interventions are less intense but more frequent than scenario 2 (no fixed intervention intervals) and promotes the presence of mature trees and snags.

Transaction costs –e.g. compilation of information for policy design and evaluation- are acknowledged to become an impediment for the development of new instruments. This is the reason why we will base the measurement of expected impacts as much as possible in existing procedures, in view of simplification, but also we will propose new indicators for those aspects missing nowadays. The cost-efficiency of this approach is compatible with the soundness of the criteria, which has been also checked.

Carbon sequestration will be measured in tonnes per hectare, using the same method that in PTGMF. Such estimation comes from the biomass as calculated in the inventory

multiplied by the species factor as identified in the Forest ecological inventory of Catalonia . The calculations come from the following formula:

$$CU_{ph} = CT_{ph} \sum BMU_i + CE_{ph} \sum BEU_i + CB_{ph} \sum BBU_i + CL_{ph} \sum BFU_i$$

where:

$CU_{ph}$  = Carbon contained in the species *Pinus halepensis*

$CT_{ph}$  = Carbon concentration in timber (see table 9)

$BMU_i$  = timber biomass of tree i

$CE_{ph}$  = Carbon concentration in bark

$BEU_i$  = bark biomass of tree i

$CB_{ph}$  = Carbon concentration in branches

$BBU_i$  = branches biomass of tree i

$CL_{ph}$  = Carbon concentration in leaves

$BLU_i$  = leaves biomass of tree i

**Table 9: Average values (x), standard deviation (s) and number of data (n) of Carbon concentration (%)**

Parameters	CT - C conc. (%) in timber			CE - C conc. (%) in bark			CB - C conc. (%) in branches			CL - C conc. (%) in leaves			Foliar Specific Weight PEF (g/cm <sup>2</sup> )		
	x	s	n	x	s	n	x	s	n	x	s	n	x	s	n
species															
<i>Pinus</i>	49	1.	182	52.	1.	173	50.	1.	181	53	2.	182	23.	3.	14
<i>halepensis</i>	.9	4		3	4		4	5		.0	1		0	0	2

Management proposed under the different scenarios will increase the carbon sequestration, in a higher amount in the case of moderate-intensity management, to medium intensity in the cases of close-to-nature and intensive management.

Biodiversity will be measured as number of different plants in the stand; We assume that fauna improvements will be correlated to the dynamics of the plant diversity indicators. Minor improvements in terms of plant diversity are foreseen to be achieved across the three scenarios, being possible to improve to the highest upgrading through the close-to-nature case, and an intermediate result with the moderate-intensity management.

In terms of recreational potential value, the study of Edwards et al, 2009 shows that for the Iberian Peninsula forest structure features determining mostly the recreational value are: visual penetration, presence of residues from silvicultural works in the forest and tree size. We will assimilate then visual penetration jointly with accessibility across the forest to the suitability for recreational uses through an adaptation of the model developed in the work of Blanco et al, 2009:

$$\ln v = \beta_1 NB + \beta_2 NT + \beta_3 D_g + \beta_4 NP_{>5} + \beta_5 NT_{<5}$$

where:

$v$  = priority of the stand with respect to scenic beauty

$NB$  = number of bushes per hectare

$NT$  = number of trees per ha

$D_g$  = basal area weighted mean diameter (cm) of trees

$NP_{>5}$  = number of pines per ha thicker than 5cm

$NT_{<5}$  = number of trees per ha with diameter at breast height less than 5cm

Recreation potential is supposed to be improved across the management scenarios in a slightly manner, being possible to reach a moderate enhancement through the moderate-intensity practices and even high increase throughout the close-to-nature model.

The levels expected to be achieved through the different scenarios are: a high resistance to fire (by intensive management), a medium resistance (in moderate-intensity management) and a slightly increase in resistance in the close-to-nature option.

#### 4.2.2.4 Mountainous region case

For instance, according to D2.1, maximization of recreational opportunities linked to wild mushroom picking is a possible scenario that our forest may face.

Among the cases recorded in the Italian forests, there are at least two main actions that affect directly the production of externalities.

The first is linked to drinkable water supply regulations, i.e. the Galli's National Act that allows Regions to introduce a component of the water tariff to compensate the maintenance costs of the catchment areas. Piedmont Region has implemented this piece of legislation to increase the forest stability in the catchment basins. In these areas the

main high forest wood harvesting regime consists in opening little gaps, let down the canopy to two third of the stem height. This operation allows reducing debris flow, flash-flood and normal flood; moreover water quality protection is assured.

The second action is referred to the already mentioned NTFPs regulations, more specifically to Wild Mushroom (WM) collection. This WM national law sets that the revenues of the permit selling must be reinvest in the forest area for a certain percentage in order to maintain or enhance WM resources. One of the most remarkable examples of the effects of this regulation is the Borgotaro mountain area (Parma Province, in Emilia Romagna Region), in which the forests are managed specifically for producing WM. The forests, mainly beech coppice, are clear-cut – on the basis of traditional knowledge - with a rotation period of 35 years leaving a hundred of standards  $\text{ha}^{-1}$  (Giovannetti *et al.*, 1998). The effect is a high WM production and a remarkable high profitability based on the large number of permits sold to tourists and professional collectors. Even so, no scientific model for WM production in highforest exists. Nevertheless, among the best silvicultural practices in highforest a suitable model is suggested by Salerni *et al.* (2004), showing that coniferous (spruce, fir) forest having  $20 \text{ m}^2 \text{ ha}^{-1}$  of basimetric area are more productive than other ones.

Recently, a voluntary market based mechanism for carbon sequestration payment has been promoted in North-East Italy through the project CARBONMARK. The theoretical approach behind this project is rooted in the REDD+ initiatives, where carbon in atmosphere is reduced by a specific forest management that prescribes an increment of the overall stock of a given forest area. Within the area where the mechanism takes place, 'close-to-nature' silviculture is suggested. Since now, only pilot tests are enforced involving a range of 40 companies buying and selling carbon credits.

Forest scenarios that may occur once the forest manager decide to target a given externality within the management plan could have different impacts on the overall forest output.

The implementation of a specific forest management plan for WM production in forest may have several effects, surely positive for the WM pickers and the forest owner in economic terms as well as the reduction of fire risk (Martínez de Aragón *et al* 2007), but also negative, because of soil constipation and general animal disturbance due to high forest frequentation. Nevertheless, a generalization of all the effects is difficult to present due to the high specific conditions in a given forest may occur. Another positive effect of rotation ages lengthening is the increased average growing stock and thus the Carbon sequestration service.

In general, almost all initiatives aimed at increasing forest profitability of Alpine forests are reducing the risks of abandonment of forest activities and therefore forest degradation, forest loss and, ultimately, the generation of negative externalities.

#### **4.2.2.5 Central European region**

The scenarios used in the CE are partly based on proposing different management strategies for different areas of the Białowieża Forest. The areas are defined according to ecological characteristics of these areas. Due to resistance of local communities this project had never been implemented<sup>4</sup>.

The hypothetical scenario of our study proposes changes in Biodiversity of the Białowieża Forest<sup>5</sup> through changes in how the each of the type areas are managed. We intend to involve natural scientists and describe in the questionnaire how each possible management strategy will affect each of respective forest types. This way we will be able to describe changes in the biodiversity of the Białowieża Forest while at the same time we will take the heterogeneity of the forest area into account. The complex biodiversity changes will be described using the “full-picture approach” – we will describe all the biodiversity and forest characteristics changes that are likely to occur as a result of a given management regime. These include the presence of i.a.: natural ecological processes, natural ecosystem components (in-forest wetland, streams, small ponds, and fallen trees), diversity of age and species of trees, the amount of dead wood, and rare species of fauna and flora.

To protect the Białowieża Forest, graduated protection zones have proposed: a strict protection zone (zone I - currently 11% of the BPF, in the future it is thought to be increased to 20%); passive protection zone (zone II - 35% of the area), in which forestry activity would be excluded and no public access was possible; active protection zone (zone III - 18%), with moderate restoration management; a restoration zone (zone IV - 36%), which would meet local demands for wood. The zones contemplated by biologists were designed partly on ecological premises (e.g. location of old-growth stands, territories of rare animals, marshes), and partly on social premises (zone IV – located on peripheries, near villages, and in the parts of the forest most seriously modified by human activity). While the main purpose of zones I and II is to secure the continuity of natural processes, zone IV will be submitted to intensive restoration management, using advanced multi-purpose forestry techniques. With the exception of zone I (strict nature protection) people will be allowed to pick mushrooms and berries, and collect deer antlers. As a result of restoration management, particularly in zone IV, the supply of firewood and raw materials will meet local needs.

---

<sup>4</sup> and is in the process of consultation with national experts

<sup>5</sup> These four types have been described in the 2.1 Report

In addition, we will propose some meaningful and feasible changes in recreational access restrictions in each of the forest types. Possible sets of recreational access restrictions to each type of the forest are:

- “GUIDED TOURS 1”, “GUIDED TOURS 2”, “SOME RESTRICTION”, “NO RESTRICTIONS (see Report 2.1; S. 5.4.3).

The attributes used in our study would thus correspond to 4 types of the forest in the Białowieża Forest. The attribute levels would be their possible management strategies which would be associated with particular biodiversity changes (as explained earlier in the questionnaire). These would have to be defined later but could include (1) strict protection, (2) active protection, (3) commercial logging and possibly one other level\*. In addition, for each forest type different recreational access opportunities would be presented. This constitutes 4 additional attributes; however, these would be presented jointly with biodiversity management changes. The alternatives of our study would be generic combinations of how each forest type is managed (with some labelled alternatives possible – to be concluded later).

**Table 10: Attributes and their levels\***

Attributes	Possible attribute levels	
	Biodiversity changes	Recreation possibilities changes
BNP forests (16,5%)	Strict protection	Recreation 1 Recreation 2 Recreation 3 Recreation 4
Natural forests outside BNP (19%)	Commercial logging Active protection Strict protection	Recreation 1 Recreation 2 Recreation 3 Recreation 4
‘Century’ forests (16%)	Commercial logging Active protection Strict protection	Recreation 1 Recreation 2 Recreation 3 Recreation 4
Remaining managed forests (48%)	Commercial logging Active protection Strict protection	Recreation 1 Recreation 2 Recreation 3 Recreation 4

Changing protection regime of the area outside the national park will have impact on each of the elements listed above. Enlarging protection area will not have impact on number of species present in the Białowieża Forest but it will increase the area where they live, and thus will impact endangered species population. For example in the BNP



there are some species of fungi and insects, so called old-growth relics, extinct elsewhere that rely on specific kinds of decaying wood. Enlarging passive protection zone will in some time result in increasing supply of dead-wood and will increase the area where these species are present. There is a close link between volume of decaying wood and presence of some species. Currently the volume of dead wood in the managed forest is from 5 to 10 times smaller than in the strict reserve in the national park.

#### 4.2.2.6 Developing country case

For our particular case study areas in the state of Amazonas (the two selected Bolsa Floresta pilots, Juma and Uatumã), at present no detailed assessment of provision costs exist. In later stages of our research, we hope to remedy this shortfall.

In the Brazilian CS area, two types of actions are intended to provide increased forest-carbon services: 1) The declaration of protected areas with improved monitoring and enforcement (M&E) measures and 2) The creation of a reward scheme for good forest stewardship called Bolsa Floresta. The protected area status allows for forest management subject to an approved management plan.

Preliminary results suggest that the costs of improving M&E measures beyond BAU are lower per intervention area unit than the costs of implementing the reward scheme.

Currently, all interventions focus on the conservation of forest-carbon stock, combined with biodiversity conservation. Stock enhancement through afforestation and reforestation is not contemplated. Technically, it is thus possible to conserve 100% of forest stocks vis-à-vis BAU levels, but this is not a politically feasible option.

For the Brazilian CS, realistic BAU management scenarios include:

- Gradual forest degradation through selective legal and illegal logging
- Forest loss through illegal deforestation by external actors
- Forest loss through illegal deforestation by internal actors

**Table 11: presents estimates for the second and third management scenario for all intervention sites of the Brazilian case study area based on historical mainly internal forest loss (scenario 2) and simulated future forest loss including caused by external actors (scenario 3).**

Reserve name	Deforestation level projected for 2050 (%)	Past deforestation 2002-8 (ha)	Past deforestation (ha/family/year)	Projected deforestation (ha/family/year)
--------------	--	--------------------------------	-------------------------------------	--

RDS CUJUBIM	0.2	15.5	0.1	2.5
RDS MAMIRAUÁ	2	9.4	0.0	0.3
RDS PIAGAÇU-PURUS	11	115.2	0.0	3.8
RDS UACARI	2	70.3	0.1	1.0
RDS UATUMÃ	70	383.1	0.2	19.8
RESEX CATUÁ-IPIXUNA	65	103.1	0.1	15.7
FLORESTA MAUÉS	68	348.4	0.1	11.2
RDS AMANÃ	1	552	0.2	1.2
RDS CANUMÃ	73	106.3	0.2	3.5
RDS JUMA	75	754.2	0.4	28.7
RDS RIO AMAPÁ	92	0.1	0.0	18.3
RDS RIO MADEIRA	70	212.8	0.1	6.8
RESEX RIO GREGÓRIO	90	323.5	0.5	86.9
RDS RIO NEGRO	88	189.1	0.1	4.7
<b>Averages</b>	<b>51</b>	<b>227.4</b>	<b>0.1</b>	<b>14.6</b>

Bolsa Floresta Program implementers expect to avoid the simulated future scenario of large scale forest loss until 2050 (scenario 2). Hence, the scenarios 1 and 3 would appear to be the most realistic given current levels of monitoring and enforcement.

### **4.3 Cost drivers in providing forest externalities**

In order to estimate the cost components, we need to get information on the drivers of forest owners preferences and production potential. We need to have information on the forest-owner characteristics that are likely to be related with the cost-components.

Those data will help us to establish a trustful comparison among the various case studies.

### 4.3.1 Theoretical framework

First, socio-economic information on forest owners are to be collected, such as average yearly income from timber production; other sources of revenue; age; level of education; size of land owned; is the forest owner the forest manager?... Interactions among forest owners and other agents are also of interest, in particular to see how the agents tackle transactions costs, and how coordination issues are handled in related areas. To do so, data are required on relationship that may exist among forest owners. Are there forest owners groups or association? Is timber production collected through cooperative systems? If any group exist, which involvement does it require for the forest owner? What are the rules to join the association? What are the decision rules inside the association? How benefits from the association shared among members?

Second, information about the forest owner's preferences are required, in order to estimate the trade off between income and externalities from forests: how do the forest owner evaluate the externalities provided by his own forest? To do so, we need to know how forest owners use their forest: time spent in forests for recreation, hunting, hiking...

Third, land tenure information can help understanding the interactions among forest owners. Land ownership structure encompasses forest owners' distribution on the land; localization; size of the parcel; relations between forest owners (association, voluntary groups...); land price; type property rights.

Fourth, information on forest management practices may help understand how forest owners use their forest resources. How much labour is used on the parcel on a yearly basis (on average)?; How much investment is spent on the parcel on a yearly basis (in average)?; What is the average quantity of timber harvested on a yearly basis; What is the habitual rotation length; Which is the type of forest management used?; Is the parcel covered by a certification scheme?; Which one?; Is the forest owner member of a forest owners association?;

Those points have to be realized both in a standard form, applicable to all the CSP in collecting all the data which could inform on the cost components.

### 4.3.2 Cost drivers in the CSP's

#### 4.3.2.1 Atlantic urbanised case

The role of producers' preferences has been investigated by Broch and Vedel (2010) through a stated preference study in relation to contracts for afforestation; they find that landowners require differentiated compensation based on the elements in the contract

(purpose (biodiversity, recreation, and groundwater protection), monitoring, and option to denounce). Heterogeneity in scheme preferences have been found in a number of other studies (Wilson & Hart 2000, Vanslebrouck et al. 2002, Hudson & Lusk 2004, Hackl et al. 2007, Ruto & Garrod 2009) indicating that landowners are likely to have different compensation requirements if they take on the role as producers.

There are several additional factors likely to affect forest owners cost of provision or willingness to accept, which can perhaps be captured either in the coming forest owner survey or using additional auxiliary information sets. It will be possible to place forest owners and their properties in a spatial context and analyze e.g. the influence of proximity to cities, local site class estimates etc. on their cost of provision. It is also possible that any local focus on e.g. groundwater resources, special biodiversity issues and the like may affect forest owners' perceptions of these issues and hence their likely willingness to accept payments for conditional environmental contracts. Spatial explicit zoning of the Danish landscape regarding biodiversity levels and hot spots, groundwater is available for such analyses. Finally, during the surveys, it should be possible also to elicit from which sources the forest owners get their alternative incomes, and the size of this. Very few forest owners in Denmark depend on the forest for their primary income, and it may be of importance also for their willingness to accept payments for providing additional environmental services.

#### **4.3.2.2 Boreal region case**

Forest owner surveys that are to be conducted in connection with WP4 could gain useful additional information on three issues related to NIPF owners' preferences: their ownership objectives, perceptions of cost components, and compensation claims (WTA compensation) for enhanced provision of environmental goods. Although costs of provision of externalities related to forests can be calculated objectively (based e.g. on opportunity costs) not related to forest owners perceptions and attitudes it may also be useful and interesting to know something about these issues. They may materialize in a situation where authorities or tourist industry wish to protect a forest stand important for a nice scenery and beautiful landscape. Moreover, in forest-based tourism areas aesthetic values and biodiversity values are produced to certain extent simultaneously and their relative demand depends on the type of clientele and their environmental preferences visiting the target area. If the owner of the stand is favourable for the protection because of environmental benefits or secondary income from tourism business he or she may be willing to accept lower compensation than the actual costs suggest or other owners may claim (see Mäntymaa et al. 2009). Using a comprehensive set of attitude questions, Karppinen (1998) created an empirical typology of non-industrial private forest owners based on forest values and long-term objectives of forest ownership, to identify these types by owner and holding characteristics, as well as to analyze silvicultural and harvesting behaviour in these groups. Applying this

typology, Kuuluvainen et al. (1996) analyzed the link between ownership objectives and observed harvesting behaviour of non-industrial private forest owners, Ovaskainen et al. (2006) the effects of cost-sharing and information assistance on nonindustrial private forest owners' investment in timber stand improvements, and Favada et al. (2009) factors affecting non-industrial private timber supply.

The objective of WP4 of the Boreal case study is to develop the idea and practical application of voluntary mechanism of Trade in Landscape and Recreational Values that would make possible to make agreements between forest owners and tourist industry. In this suggested mechanism (Temisev  et al. 2008) the financing of improved environmental quality could be collected from the beneficiaries/users of landscape collectively in the price of nature-based tourism services. Compensation for forest owners would be paid from the development payment fund including wide range of forest management options.

In order to support this process, the study by Horne et al. (2009) will be relevant. Related to a set of incentive-based policy instruments of Forest Biodiversity Programme for Southern Finland (METSO) they examined the attitudes of Finnish non-industrial private forest owners towards the safeguarding of forest biodiversity, its socio-economic effects, compensation policy, and policy instruments. Using choice experiment method in the same context, Horne (2006) examined the factors that affect the acceptability of biodiversity conservation contracts among private forest owners, and the amount of compensation needed to keep the forest owners at least as well off as before the contract. Attributes used in the study, i.e. initiator of the contract, restrictions on forest use, amount of compensation, duration of contract and cancellation policy, may be critical also in our case.

#### **4.3.2.3 The Mediterranean region case**

Campos et al, 2008 lists labour, machinery work, and fossil fuels as relevant, costly inputs.

In addition, we typically find as requested factors for budget assessments in the area (Forestal Catalana, 2010): Initial tree density, Slops, Roads presence, Market prices, Concentration of recreationists.

#### **4.3.2.4 Central European region**

In assessing the cost drivers, we can list the following data for which we have indicators: timber production, timber revenue, timber prices in the area, tree species and age structure, species composition in National park versus managed forest, dead wood, certification and employment

#### 4.3.2.5 Developing country case

Little empirical knowledge exists with regard to producer preferences. A recent study in one of the case study sites suggests, based on descriptive statistics, that small-scale producers living inside the Juma reserve attach a relatively high value to standing forests, mainly as sources of multiple livelihood benefits (Agustsson *et al.*, 2010). 64% of respondents reported, that the Bolsa Floresta Program had changed their attitude towards forests in terms of attaching higher values to conservation. Forests do however also represent the major sources of nutrients for slash-and-burn agriculture, a major of staple food provider. As a result we expect that reserve dwellers derive rather low marginal benefits from increasing slash-and-burn activities, whereas external actors who derive little or no benefits from forest conservation realize high returns to, e.g. illegal logging, in the absence of effective monitoring and enforcement.

### 4.4 Cost assessment

Once the assessment of forest owners' preferences, BAU and management scenarios has been made, it is then possible to assess the cost of additional externality provision, considering our basic model.

The total cost of additional externality provision for the forest owner is:  $C = U(M^*) - U(M^{EX})$ . This total cost is composed of several cost components: direct cost  $DC$ , opportunity costs  $OC$ , feedback costs  $EC$ . In our simplified specification, the cost composition may be written:  $C = \alpha(DC + OC) + (1 - \alpha)EC$ .

The direct costs (or investments or implementation costs) are the costs of undertaking the change in forest management practices (extra capital, operating costs). It could be the cost of equipment for recreation, or the cost of changing timber species. This direct cost may be written as:  $DC = c(M_j^{EX}) - c(M_j^*)$ . More generally, if a production cost function can be estimated, the direct cost of externality provision may be assessed by:  $\frac{\partial c(M_j)}{\partial M_j}$ .

The opportunity costs in terms of forest management or other land use choice (loss in timber income and costs associated with forgone land uses), is the profit loss from timber harvesting, relative to the BAU option (productivity, inputs, harvesting quantity and frequency, timber prices). It can be written as:  $OC = Y(M^*) - Y(MEX) - c(M_{-j}^*) - c(M_{-j}^{EX})$ . More generally, if a profit function can be estimated, the opportunity cost of externality provision may be assessed by:  $\frac{\partial \Pi(M)}{\partial M}$ .

The feedback costs are the feedback effects on other forest externalities (more recreation and less biodiversity) and on other land uses (for ex, the protection of biodiversity in forest can be potentially damaging to some culture in agricultural lands). In the following model, the feedback costs may be written as:  $EC = U_A(A_{-i}^*) - U_A(A_{-i}^{EX})$ . More generally, if an externalities utility function can be estimated, the direct cost of externality provision may be assessed by:  $\frac{\partial U_A(M_j)}{\partial M_j}$ . Note that this cost can be negative.

For instance, management practices favoring biodiversity may also increase the benefit from recreation.

In this simple model, no transaction costs are considered. An advantage of this simple specification is that we do not need to specify forest profit function, since we only make comparative statics of two situations: the BAU and the additional provision scenario. We thus compare two situations in which the forest owner already made his utility maximization. We need to get information on the forest owners' profit under the two scenarios, and an estimation of their environmental preferences (how do forest owners value the externalities they voluntarily provide under BAU).

It is possible to introduce several extensions to this benchmark model, depending on the relevant points to be examined.

First, we may explicit which policy is implemented, and how the costs evolves depending on the policy options: taxes, subsidies, PES, contracts...

Second, we may introduce inter-dependency among forest owners: forest externalities provided by one forest owner may have influence on other forest owners' utility:  $U_f(M_f, M_{-f})$ .

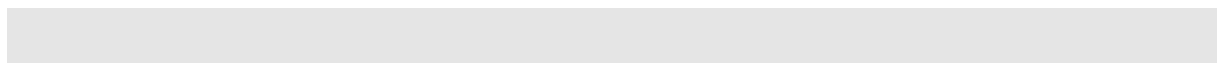
Third, we may consider the fact that the forest owner is not necessarily the forest manager, and that both agents may have different preferences. We could then imagine a model of principal agent between a forest owner with given preferences, and a forest manager with different preferences, and investigate the potential implications.

Fourth, we may introduce incomplete information about the real outcomes in terms of forest externalities: how do forest management practices are related to externalities provision? From the introduction of incomplete information, we could investigate some transaction costs.

As shown here, the basic model that we provide allows to assess the different components of the cost of externality provision. Moreover, its flexible nature should allow us to eventually consider potential idiosyncrasies that may be noticed in the



different case studies (industrial vs non-industrial forest owners, for instance). This assessment depends on the available data that we have to collect on forest owners' socio-economic variables, preferences, and forest management practices.



## 5. REFERENCES

### 5.1 FRANCE

- Alchian, A. A., 1996. Some economics of property rights. Privatization: critical perspectives on the world economy 294-294.
- Alessi, L. D., 1983. Property rights, transaction costs, and X-efficiency: an essay in economic theory. *The American Economic Review* 73, 64-81.
- Allen, D. W., 1991. What are transaction costs. *Research in Law and Economics* 14, 1-18.
- Andersson, M., Gong, P. C., 2010. Risk preferences, risk perceptions and timber harvest decisions - An empirical study of nonindustrial private forest owners in northern Sweden. *Forest Policy and Economics* 12, 330-339.
- Antle, J. M., Valdivia, R. O., 2006. Modelling the supply of ecosystem services from agriculture: a minimum-data approach. *Australian Journal Of Agricultural And Resource Economics* 50, 1-15.
- Antoci, A., 2009. Environmental degradation as engine of undesirable economic growth via self-protection consumption choices. *Ecological Economics* 68, 1385-1397.
- Asante, P., Armstrong, G.W., Adamowicz, W.L., 2010. Carbon sequestration and the optimal harvest decision: A dynamic programming approach considering biomass and dead organic matter. *Journal of Forest Economics* In Press.
- Barzel, Y., 1997. *Economic analysis of property rights*, Cambridge Univ Pr.
- Baskent, E. Z., Baskaya, S., Terzioglu, S., 2008. Developing and implementing participatory and ecosystem based multiple use forest management planning approach (ETCAP): Yalnizcam case study. *Forest Ecology and Management* 256, 798-807.
- Baskent, E. Z., Terzioglu, S., Baskaya, S., 2008. Developing and implementing multiple-use forest management planning in Turkey. *Environmental Management* 42, 37-48.
- Becker, G. S., 1965. A Theory of the Allocation of Time. *The Economic Journal* 75, pp. 493-517.
- Binkley, C., 1981. *Timber supply from nonindustrial forests: a microeconomic analysis of landowner behavior*, Yale University Press, New Haven, CT.
- Borner, J., Mburu, J., Guthiga, P., Wambua, S., 2009. Assessing opportunity costs of conservation: Ingredients for protected area management in the Kakamega Forest, Western Kenya. *Forest Policy and Economics* 11, 459-467.
- Boscolo, M., Vincent, J. R., 2003. Nonconvexities in the production of timber, biodiversity, and carbon sequestration. *Journal of Environmental Economics and Management* 46, 251-268.
- Bowes, M. D., Krutilla, J.V., 1989. *Multiple-use management: The economics of public forestlands, Resource for the future*, Washington, D.C.
- Coase, R. H., 1937. The nature of the firm. *Economica* 4, 386-405.
- Coase, R. H., 1960. The problem of social cost. *Journal of Law and Economics* 3, 1-44.
- Collins, English Dictionary, Collins UK.
- Demsetz, H., 1966. Some aspects of property rights. *Journal of Law and Economics* 9, 61-70.

- Demsetz, H., 1988. The theory of the firm revisited. *Journal of Law, Economics, and Organization* 4, 141-161.
- Demsetz, H., 1997. *The economics of the business firm: seven critical commentaries*, Cambridge University Press.
- Egdell, J. 1998. A transaction costs approach to the development of agri-environmental policy, using the example of Scotland. Annual Conference of the Agricultural Economics Society Reading, England.
- Falconer, K., 2000. Farm-level constraints on agri-environmental scheme participation: a transactional perspective. *Journal of Rural Studies* 16, 379-394.
- Falconer, K., Whitby, M., 2000. Untangling red tape: scheme administration and the invisible costs of European agri-environmental policy. *European Environment* 10, 193-203.
- Fang, F., Easter, K. W., Brezonik, P. L., 2005. Point-nonpoint source water quality trading: a case study in the Minnesota river basin. *Journal of the American Water Resources Association* 41, 645-657.
- Faustmann, M., 1849. Calculation of the value which forest land and imature stands possess for forestry. *Allgemeine Forst-und Tagde Zeitung, Tagde Zeitung* 441-455.
- Faustmann, M., 1995. Calculation of the value which forestland and immature stands possess for forestry. Reprinted in *Journal of Forest Economics* 1, 7-44.
- Fiquepron, J., Garcia, S., Stenger, A., 2009. Forests adding value to water quality in a land use perspective, Mimeo LEF.
- Fullerton, D., 2001. A framework to compare environmental policies. *Southern Economic Journal* 68, 224-248.
- Gadaud, J., Rambonilaza, M., 2010. Amenity values and payment schemes for free recreation services from non-industrial private forest properties: A French case study. *Journal of Forest Economics* 16, 297-311.
- Gordon, R. L., 1994. *Regulation and Economic analysis: a critique over two centuries*, Springer.
- Grieg-Gran, M. 2006. The cost of avoiding deforestation in the stern review of the economics of climate change. IED (International Institute for Environment and Development).
- Haltia, E., Kuuluvainen, J., Ovaskainen, V., Pouta, E., Rekola, M., 2009. Logit model assumptions and estimated willingness to pay for forest conservation in southern Finland. *Empirical Economics* 37, 681-691.
- Hartman, R., 1976. The harvesting decision when a standing forest has value. *Economic Inquiry* 14, 52-58.
- Havlik, P., Veyssset, P., Boisson, J. M., Lherm, M., Jacquet, F., 2005. Joint production under uncertainty and multifunctionality of agriculture: policy considerations and applied analysis. *European Review of Agricultural Economics* 32, 489-515.
- Hof, J. G., Lee, R. D., Dyer, A. A., Kent, B. M., 1985. An analysis of joint costs in a managed forest ecosystem. *Journal of Environmental Economics and Management* 12, 338-352.
- Huhtala, A., Pouta, E., 2008. User fees, equity and the benefits of public outdoor recreation services. *Journal of Forest Economics* 14, 117-132.
- J. Singh, L. S., Strauss, J., 1988. *Agricultural household models: Extension, application and policy* : Inderjit J. Singh, Lyn Squire and John Strauss, eds. (Johns Hopkins University Press, Baltimore, MD, 1986) pp. xi+335, \$37.50. *Journal of Development Economics* 28, 147-151.

- Juutinen, A., Luque, S., Monkkonen, M., Vainikainen, N., Tomppo, E., 2008. Cost-effective forest conservation and criteria for potential conservation targets: a Finnish case study. *Environmental Science and Policy* 11, 613-626.
- Juutinen, A., Monkkonen, M., Ylisirnio, A. L., 2009. Does a voluntary conservation program result in a representative protected area network? The case of Finnish privately owned forests. *Ecological Economics* 68, 2974-2984.
- Kilgore, M. A., Snyder, S., Taff, S., Schertz, J., 2008. Family forest stewardship: do owners need a financial incentive? *Journal of Forestry* 106, 357-362.
- Kilgore, M. A., Snyder, S. A., Schertz, J., Taff, S. J., 2008. What does it take to get family forest owners to enroll in a forest stewardship-type program? *Forest Policy and Economics* 10, 507-514.
- Kline, J. D., Alig, R. J., Johnson, R. L., 2000. Forest owner incentives to protect riparian habitat. *Ecological Economics* 33, 29-43.
- Kline, J. D., Alig, R. J., Johnson, R. L., 2000. Fostering the production of nontimber services among forest owners with heterogeneous objectives. *Forest Science* 46, 302-311.
- Kuperan, K., Abdullah, N. M. R., Pomeroy, R. S., Genio, E. L., Salamanca, A. M., 2008. Measuring transaction costs of fisheries co-management. *Coastal Management* 36, 225-240.
- Layton, D. F., Siikamäki, J., 2009. Payments for ecosystem services programs: predicting landowner enrollment and opportunity cost using a beta-binomial model. *Environmental and Resource Economics* 44, 415-439.
- Le Cotty, T., Voituriez, T., 2003. Multifunctionality and non-agricultural supply of public goods. *Proceedings of the 25th International Conference of Agricultural Economists*. Durban, South Africa.
- Lee, K. J. 1997. Hedonic estimation of nonindustrial private forest landowner amenity values. Unpublished PhD dissertation, North Carolina State University.
- Leffler, K. B., Rucker, R. R., 1991. Transactions costs and the efficient organization of production: a study of timber-harvesting contracts. *The Journal of Political Economy* 99, 1060-1087.
- Martinez-Cruz, D. A., Bustamante-Gonzalez, A., Jaramillo-Villanueva, J. L., Silva-Gomez, S. E., Tornero-Campante, M. A., Vargas-Lopez, S., 2010. Willingness to accept payments by forest owners for maintaining hydrologic environmental services. *Tropical and Subtropical Agroecosystems* 12, 549-556.
- Matta, J., Alavalapati, J., Tanner, G., 2007. A framework for developing market-based policies to further biodiversity on non-industrial private forests (NIPF). *Forest Policy and Economics* 9, 779-788.
- Mccann, L., Easter, K.W., 2000. Estimates of public sector transaction costs in NRCS programs. *Journal of agricultural and applied economics* 32, 555-564.
- Mccann, L., Colby, B., Easter, K. W., Kasterine, A., Kuperan, K. V., 2005. Transaction cost measurement for evaluating environmental policies. *Ecological Economics* 52, 527-542.
- Michael, J. A., 2003. Efficient habitat protection with diverse landowners and fragmented landscapes. *Environmental Science & Policy* 6, 243-251.
- Montgomery, C. A. 2002. Compatibility of timber and conservation: Tracing the tradeoff frontier. USDA Forest Service General Technical Report Pacific Northwest. Portland, US Department of Agriculture, Forest Service Pacific Northwest Research Station.
- Nalle, D. J., Montgomery, C. A., Arthur, J. L., Polasky, S., Schumaker, N. H., 2004. Modeling joint production of wildlife and timber. *Journal of Environmental Economics and Management* 48, 997-1017.

- Newman, D. H., Wear, D. N., 1993. Production economics of private forestry: a comparison of industrial and nonindustrial forest owners. *American Journal of Agricultural Economics* 75, pp. 674-684.
- Noel, J. F., O'Connor, M., Sang, J. T. K., 2000. The Bouchereau woodland and the transmission of socio-ecological economic value. *Ecological Economics* 34, 247-266.
- North, D. C., 1990. *Institutions, institutional change, and economic performance*, Cambridge Univ Pr.
- Oliver, P. E., 1993. Formal models of collective action. *Annual Review of Sociology* 19, 271-300.
- Olson, M., 1971. *The logic of collective action: public goods and the theory of groups*, Harvard University Press.
- Pattanayak, S. K., Murray, B. C., Abt, R. C., 2002. How joint is joint forest production? An econometric analysis of timber supply conditional on endogenous amenity values. *Forest Science* 48, 479-491.
- Pattanayak, S. K., Abt, K. L., Holmes, T. P. *Timber and amenities on nonindustrial private forest land. Forests in a Market Economy*. Kluwer Academic Publishers: The Netherlands.
- Peerlings, J., Polman, N., 2004. Wildlife and landscape services production in Dutch dairy farming: jointness and transaction costs. *European Review of Agricultural Economics* 31, 427-449.
- Pradeep, C., Tewari, V. P., Singh, B., 2008. WTP vs WTA for assessing the recreational benefits of urban forests: a case from a modern and planned city of a developing country. *Forests, Trees and Livelihoods* 18, 215-231.
- Raunikaar, R., Buongiorno, J., 2006. Willingness to pay for forest amenities: The case of non-industrial owners in the south central United States. *Ecological Economics* 56, 132-143.
- Sanjana, P., Barcus, M. J., Bangs, M. J., Ompusunggu, S., Elyazar, I., Marwoto, H., Tuti, S., Sururl, M., Tjokrosonto, S., Baird, J. K., 2006. Survey of community knowledge, attitudes, and practices during a malaria epidemic in central Java, Indonesia. *American Journal of Tropical Medicine and Hygiene* 75, 783-789.
- Scarpa, R., Buongiorno, J., Hseu, J., Abt, K. L., 2000. Assessing the non-timber value of forests: a revealed-preference, hedonic model. *Journal of Forest Economics* 6, 83-107.
- Shaikh, S. L., Sun, L. L., Van Kooten, G. C., 2007. Are agricultural values a reliable guide in determining landowners' decisions to create forest carbon sinks? *Canadian Journal of Agricultural Economics-Revue Canadienne D Agroeconomie* 55, 97-114.
- Shelanski, H. A., Klein, P. G., 1995. Empirical research in transaction cost economics: a review and assessment. *Journal of Law, Economics, and Organization* 11, 335-361.
- Silva-Flores, R., Perez-Verdin, G., Navar-Chaidez, J. D., 2010. Economic valuation of the hydrological environmental services in El Salto, Pueblo Nuevo, Durango. *Madera Y Bosques* 16, 29-47.
- Singh, I., Squire, L., Strauss, J., 1986. *Agricultural household models: extensions, applications, and policy*, Johns Hopkins University Press, Baltimore M.D.
- Srivastava, A., Ganguly, A., 2010. Indifference curves as a tool for environment impact assessment. *Environmental Monitoring and Assessment* 160, 513-519.
- Stavins, R. N., 1995. Transaction costs and tradeable permits. *Journal of Environmental Economics and Management* 29, 133-148.
- Sullivan, J., Amacher, G. S., Chapman, S., 2005. Forest banking and forest landowners forgoing management rights for guaranteed financial returns. *Forest Policy and Economics* 7, 381-392.

- Tahvonen, O., Salo, S., 1999. Optimal forest rotation within situpreferences. *Journal of Environmental Economics and Management* 37, 106-128.
- Thompson, D. B., 1999. Beyond benefit-cost analysis: institutional transaction costs and regulation of water quality. *Natural Resources Journal* 39, 517-517.
- Vatn, A. 2001. Transaction costs and multifunctionality. OECD Workshop on multifunctionality, Paris.
- Vernimmen, T., Verbeke, W., Huylenbroeck, G. V., 2000. Transaction cost analysis of outsourcing farm administration by Belgian farmers. *European Review of Agricultural Economics* 27, 325-345.
- Vokoun, M., Amacher, G. S., Sullivan, J., Wear, D., 2010. Examining incentives for adjacent non-industrial private forest landowners to cooperate. *Forest Policy and Economics* 12, 104-110.
- Vokoun, M., Amacher, G. S., Wear, D. N., 2006. Scale of harvesting by non-industrial private forest landowners. *Journal of Forest Economics* 11, 223-244.
- Wallis, J. J., North, D. C., 1986. Measuring the transaction sector in the american economy, 1870-1970.
- Wikberg, S., Perhans, K., Kindstrand, C., Djupstrom, L. B., Boman, M., Mattsson, L., Schroeder, L. M., Weslien, J., Gustafsson, L., 2009. Cost-effectiveness of conservation strategies implemented in boreal forests: The area selection process. *Biological Conservation* 142, 614-624.
- Williamson, O. E., 1985. *The economic institutions of capitalism*, Free press, New York.
- Zandersen, M., Termansen, M., Jensen, F. S., 2007. Testing benefits transfer of forest recreation values over a twenty-year time horizon. *Land Economics* 83, 412-440.

## 5.2 DENMARK

- Abildtrup, J., Strange, N., 1999. The option value of non-contaminated forest watersheds. *Forest Policy and Economics* 1, 115-125.
- Anthorn, S., Jacobsen, J.B., Thorsen, B.J. 2003. Skovenes mulige rolle i klimapolitikken: En scenario analyse af CO<sub>2</sub>-reduktionspotentiale og marginale økonomiske omkostninger. [The Potential Role of Forests in the Climate Change Policy: A Scenario Analysis of CO<sub>2</sub>-sequestration Potential and Marginal Costs]. Report for the Forest and Nature Agency, Ministry of Environment, Denmark, 59 pp.
- Boon T.E., 2003. Hvad mener de danske skovejere? Spørgeundersøgelse blandt private skovejere i Danmark [Survey of private forest owners in Denmark]. Skovbrugsserien nr. 33, Skov and Landskab (FSL), Hørsholm.
- Boon, T.E., Meilby, H., Thorsen, B.J., 2004. An empirically based typology of private forest owners in Denmark – improving the communication between authorities and owners. *Scandinavian Journal of Forest Research* 19 (4), 45-55.
- Boon, T. E., Meilby, H., 2007. Describing management attitudes to guide forest policy implementation. *Small-Scale Forestry* 6, 79-92.
- Broch, S. W., Vedel, S. E., 2010. Contract design from a landowner perspective. Paper presented at the Scandinavian Society of Forest Economics Conference, 19-22 May. 2010, Gilleleje, Denmark.
- Brukas, V., Hjortsø, N., Tarp, P., Boon, T. E., 1999. Public participation in forest management planning supported by multi-criteria decision-making techniques. In: Helles, F., Holten-Andersen, P., Wichmann, L., Multiple use of forests and other natural resources, *Forestry Sciences* 61. Kluwer Academic Publishers, The Netherlands.

Church, A., Ravenscroft, N., 2008. Landowner response to financial schemes for recreational access to woodlands in South East England. *Land Use Policy* 25, 1-16.

EFORWOOD report, 2007. EFORWOOD, Tools for Sustainability Impact Assessment, Project no. 518128. Thematic Priority: 6.3 Global Change and Ecosystems. Deliverable D 2.2.2. Synthesis report on impact of forest management on environmental services

Hackl, F., Halla, M., Pruckner, G. J., 2007. Local compensation payments for agri-environmental externalities: a panel data analysis of bargaining outcomes. *European Review of Agricultural Economics* 34(3), 295-320.

Hudson, D., Lusk, J., 2004. Risk and transaction cost in contracting: Results from a choice-based experiment. *Journal of Agricultural & Food Industrial Organizations* 2(1), 1-17.

Humphrey, J. W., Holl, K. and Broome, A. C., 1998. Birch in spruce plantations: management for biodiversity. Forestry Commission Technical Paper 26. Forestry Commission, Edinburgh.

Humphrey, J. W., Newton, A. C., Peace, A. J. and Holden, E., 2000. The importance of conifer plantations in northern Britain as a habitat for native fungi. *Biological Conservation* 96, 241-252.

Hyvönen, R., Ågren, G. I., Linder, S., Persson, T., Cotrufo, M. F., Ekblad, A., Freeman, M., Grelle, A., Janssens, I. A., Jarvis, P. G., Kellomäki, S., Lindroth, A., Loustau, D., Lundmark, T., Norby, R. J., Oren, R., Pilegaard, K., Ryan, M. G., Sigurdsson, B. D., Strömberg, M., Van Oijen, M. and Wallin, G., 2007. The likely impact of elevated [CO<sub>2</sub>], nitrogen deposition, increased temperature and management on carbon sequestration in temperate and boreal forest ecosystems: a literature review. *New Phytologist* 173: 463-480.

Jacobsen, J.B., Thorsen, B.J., 2010b. Tabsberegninger ved driftsrestriktioner for forskellige skovnaturtyper i Natura 2000 – ego g ask [Business economic loss estimates related to management restrictions in different forest nature types in NATURA 2000 – Oak and Ash]. Report for the Danish Forest- and Nature Agency.

Jensen, F.S., 1999. Changes in the forest preferences of the Danish population from 1977 to 1994. In: Jensen, F.S., 1999. Forest recreation in Denmark from the 1970s to the 1990s. The Research Series 26, The Royal Veterinary and Agricultural University and Forskningscentret for Skov og Landskab, Hørsholm, pp. 129-166.

Paillet, Y., Bergès, L., Hjältén, J., Ódor, P., Avon, C., Bernhardt-Römermann, M., Bijlsma, R.-J., de Bruyn, L., Fuhr, M., Grandin, U., Kanka, R., Lundin, L., Luque, S., Magura, T., Matesanz, S., Mészáros, I., Sebastià, M.-T., Schmidt, W., Standovár, T., Tóthmérész, B., Uotila, A., Valladares, F., Vellak, K. and Virtanen, R. 2010. Biodiversity Differences between Managed and Unmanaged Forests: Meta-Analysis of Species Richness in Europe. *Conservation Biology* 24: 101-112.

Patterson, G.S. 1993. The value of birch in upland forests for wildlife conservation. Bulletin 109. Forestry Commission, Edinburgh.

Raulund-Rasmussen, K., Hansen, K., (eds.). 2003. Grundvand fra skove - muligheder og problemer [Ground water from forests – opportunities and issues. Skovbrugsserien 34, Skov & Landskab, Hørsholm, pp. 122.

Ruto, E., Garrod, G., 2009. Investigating farmers' preferences for the design of agri-environmental schemes: a choice experiment approach. *Journal of Environmental Planning and Management* 52(5), 631-647.

Rusterholz, H., Bilecen, E., Kleiber, O., Hegetschweiler, K. T., Baur, B., 2009. Intensive recreational activities in suburban forests: A method to quantify the reduction in timber value, *Urban Forestry and Urban Greening* 8, 109-116.



Strange, N., Brukas, V., Helles, F., Tarp, P., 2003. Comparison of multi-criteria optimization techniques for selection of conservation areas. In: Helles, F., Strange, N., Wichmann, Recent accomplishments in applied forest economics research, Forestry Sciences 74. Kluwer Academic Publishers, The Netherlands.

Strange, N., Tarp, P., Helles, F., Brodie, J. D., 1999. A four-stage approach to evaluate management alternatives in multiple-use forestry, *Forest Ecology and Management* 124, 79-91.

Strange, N., H. Meilby and B.J. Thorsen, 2002: Optimization of land use in afforestation areas using evolutionary self-organisation, *Forest Science*, 48, 543-555.

Tarp, P., Helles, F., Holten-Andersen, P., Larsen, J. B., Strange, N., 2000. Modelling near-natural silvicultural regimes for beech – an economic sensitivity analysis. *Forest Ecology and Management* 130, 187-198.

Thorsen, B.J. and H.M. Hedegaard, 2003: Økonomiske perspektiver ved udnyttelse af grundvand fra skovene [Economic aspects of the provision and use of groundwater from the forests], p. 111-120 in Raulund-Rasmussen, K., Hansen, K., (eds.). 2003. Grundvand fra skove - muligheder og problemer [Ground water from forests – opportunities and issues. Skovbrugsserien 34, Skov & Landskab, Hørsholm, pp. 122.

Urquhart, J., Courtney, P., Slee, B., 2010. Private ownership and public good provision in English woodlands. *Small-scale Forestry* 9, 1-20.

Vanslebrouck, I., Van Huylenbroeck, G., Verbeke, W., 2002. Determinants of willingness of Belgian farmers to participate in agri-environmental measures. *Journal of Agricultural Economics* 53(3), 489-511.

Vedel, S.E., Jacobsen, J.B., Thorsen, B.J., 2010. Tabsberegninger ved driftsrestriktioner for forskellige skovnaturtyper i Natura 2000 – bøg [Business economic loss estimates related to management restrictions in different forest nature types in NATURA 2000 - Beech]. Report for the Danish Forest- and Nature Agency.

Vedel, S.E., J.B. Jacobsen and B.J. Thorsen, 2010: Contracts for environmental goods and the role of monitoring for landowners' willingness to accept. Paper presented at the 5th World Conference of ERE, Montreal, June 28-July 2, 2010, 22 pp.

Wilson, G. A., Hart, K., 2000. Financial imperative or conservation concern? EU farmers' motivation for participation in voluntary agri-environmental schemes. *Environment and Planning A* 32, 2161-2185.

### 5.3 ITALY

Bonnieux, F., Desaignes, B., 1998. *Economie et politiques de l'environnement*, Précis Dalloz, Paris

Bowes, M.D. Krutilla, J.V., 1989. Multiple Use Management: the Economics of public Forestlands, Resources for the Future, Washington D. C.

CARBONMARK project URL: <http://www.carbomark.org/index.php?q=en/node/49>

Campos, P., 2004. Developing and Applying a Forest Integrated Economic System of Accounts for Measuring Total Sustainable Income: Five case Studies in Mediterranean Mountain Areas. MEDMONT - Tools for evaluating investment in the Mediterranean Mountain areas: An integrated framework for sustainable development EU-QLK5-2000-01031.

Canton, A. Pettenella, D., 2010. Motivazioni gestionali dei proprietari forestali privati: un caso di studio nel comune di Recoaro Terme (VI). *Forest@* 7, 44-57 [online: 2010-04-01] URL: <http://www.sisef.it/forest@/>.

Ciancio, O., Corona, P., Marinelli, M., Pettenella, D., 2007. Evaluation of forest fire damages in Italy. Firenze: Accademia Italiana di Scienze Forestali.

Gatto, P., Merlo, M., 1999. The economic nature of stewardship: complementarity and trade-offs with food and fibre production. In: Van Huylenbroeck G. and Whitby M. (eds.) *Countryside Stewardship: Farmers, Policies and Markets*. Elsevier: Oxford, pp. 21-46.

Giovannetti, G., Zingari, P., Terzolo, P., 1998. Exploitation of forest productivity through increased mushroom production. *Acta Hort* 457, 127-132.

Martínez de Aragón, J., Bonet, J.A., Fischer, C.R., Colinas C., 2007. Productivity of ectomycorrhizal and selected edible saprotrophic fungi in pine forests of the pre-Pyrenees mountains, Spain: Predictive equations for forest management of mycological resources. *Forest Ecology and Management* 252, 239–256

Mezzalana, G., Monaci, M., Cogato, A., Astolfi, L., 2008. Assessing the Value of Wastewater Purification Carried out by Forest filter Areas: a First Attempt in the Venetian Plain. In: Cesaro L., Gatto P. and Pettenella D. (eds) *The Multifunctional Role of Forests – Policies Methods and Case-studies*. EFI Proceedings N. 55, 2008.

Notaro, S., Paletto, A., Raffaelli, R., 2008. The economic valuation of Non-productive Forest Functions as an Instruments towards Integrated Forest Management. In: Cesaro L., Gatto P. and Pettenella D. (eds) *The Multifunctional Role of Forests – Policies Methods and Case-studies*. EFI Proceedings No. 55.

Pettenella, D., Kloehn, S., 2007. Mediterranean mushrooms: how to market them. In: Berrahmouni N., Escuté X., Regato P. and Stein C. (eds) 2007 – *Beyond Cork – a wealth of resources for People and Nature*. WWF Mediterranean and IPADE, Madrid, 2007, p. 52-68.

Rupf, H., 1960. Wald und Mensch im Geschehen der Gegenwart. *Allgemeine Forstzeitschrift* 38, 545- 552.

Salerni, E., Perini, C., 2004. Experimental study for increasing productivity of *Boletus edulis* s.l. in Italy. *Forest Ecology and Management* 201, 161-170.

Tassone, V.C., Wesseler, J., Nesci, F.S., 2004. Diverging incentives for afforestation from carbon sequestration. *Forest Policy and Economics* 6 567-578.

Tassone, V.C., Wesseler, J., Kros, H., Nesci, F.S., 2008. Effects of Environmental Benefits from Afforestation on Optimal Harvesting Age in a Mediterranean Marginal Area. In: Cesaro L., Gatto P. and Pettenella D. (eds) *The Multifunctional Role of Forests – Policies Methods and Case-studies*. EFI Proceedings N. 55.

## 5.4 BRAZIL

Agustsson, K., Garibjana, A., Rojas, E.C.S., 2010. An assessment of initial impacts of applying a payment for environmental services programme on forest protection and livelihood security, Norwegian University of Life Science, As.

Börner, J., Denich, M., Mendoza-Escalante, A., Hedden-Dunkhorst, B., Abreu Sá, T., 2007. Alternatives to slash-and-burn in forest-based fallow systems of the eastern Brazilian Amazon region: Technology and policy options to halt ecological degradation and improve rural welfare. In *Stability of Tropical Rainforest Margins* (eds M. Zeller, T. Tschardtke, C. Leuschner, S. Schwarze, R. Weber, H. Faust, B. Schippers, W. Kreisel & A. Tewe), pp. 333-361. Springer, Berlin-Heidelberg.

Börner, J., Mendoza, A., Vosti, S.A., 2007. Ecosystem services, agriculture, and rural poverty in the Eastern Brazilian Amazon: Interrelationships and policy prescriptions. *Ecological Economics* 64, 356-373.

Börner, J., Wunder, S., 2008. Paying for avoided deforestation in the Brazilian Amazon: From cost assessment to scheme design. *International Forestry Review* 10, 496-511.

Börner, J., Wunder, S., Wertz-Kanounnikoff, S., Tito, M.R., Pereira, L., Nascimento, N., 2010. Direct conservation payments in the Brazilian Amazon: Scope and equity implications. *Ecological Economics* 69, 1272-1282.

Carpentier, C.L., Vosti, S., Witcover, J., 2002. Small-scale farms in the western Brazilian Amazon: can they benefit from carbon trade? International Food Policy Research Institute (IFPRI), Washington D.C.

Klemick, H., in press. Shifting cultivation, forest fallow, and externalities in ecosystem services: Evidence from the Eastern Amazon. *Journal of Environmental Economics and Management*, In Press, Corrected Proof.

Nepstad, D., Soares-Filho, B.S., Merry, F., Moutinho, P., Rodrigues, H.O., Bowman, M., Schwartzman, S., Almeida, O., Rivero, S., 2007. The costs and benefits of reducing carbon emissions from deforestation and forest degradation in the Brazilian Amazon.

## 5.5 POLAND

Bartczak, A., Lindhjem, H., Navrud, S., Zandersen, M., Zylicz, T., 2008. Valuing forest recreation on the national level in a transition economy: The case of Poland. *Forest Policy and Economics* 10, 467-472.

Czajkowski, M., Buszko-Briggs, M., Hanley, N., 2009. Valuing changes in forest biodiversity. *Ecological Economics* 68, 2910-2917.

Giergiczny, M., 2009. Rekreacyjna wartość Puszczy Białowieskiej zastosowanie strefowego modelu kosztu podróży. *Ekonomia i Środowisko*, 3, [Applying Zonal Travel Cost Model to estimate recreational value of the Białowieza Forest]

## 5.6 FINLAND

Anonymous 2009. Statistical Yearbook of Forestry 2008. 450 p

Anonymous 2006. Hyvän metsänhoidon suositukset. [Silvicultural recommendations for Finland.] In Finnish. 101 pages. Metsätalouden Kehittämiskeskus Tapio.

Besley, T., Coate, S., 2003. Centralized versus decentralized provision of local public goods: a political economy approach. *Journal of Public economics* 87, 2611-2637.

Bestard, A.B., Font, A.R., 2010. Estimating the aggregate value of forest recreation in a regional context. *Journal of forest economics* 16, 205-216.

Blanco, E., Rey-Maqueira, J., Lozano, J., 2009. Economic incentives for tourism firms to undertake voluntary environmental management. *Tourism management* 30, 112-122.

Cao, T., Valsta, L., Mäkelä, A., 2010. A comparison of carbon assessment methods for optimizing timber production and carbon sequestration in Scots pine stands. *Forest ecology and management* 260, 1726-1734.

Dwyer, L., Fosryth, P., Spurr, R., 2004. Evaluating tourism's economic effects: new and old approaches. *Tourism management* 25, 307-317.

Edwards, D., Jensen, F.S., Marzallo, M., Mason, B., Pizzirani, S., Schelhaas, M-J., 2009. A theoretical framework to assess the impacts of forest management on the recreational value of European forests. *Ecological indicators* 2009, article in press. doi:10.1016/j.ecolind.2009.06.006

Favada, I.M., Karppinen, H., Kuuluvainen, J., Mikkola, J., Stavness, C., 2009. Effects of timber prices, ownership objectives, and owner characteristics on timber supply. *Forest Science* 55(6), 512-523.

- Gadaud, J., Rambonilaza, M., 2010. Amenity values and payment schemes for free recreation services from non-industrial private forest properties: a French case study. *Journal of forest economics* 2010, article in press. doi: 10.1016/j.jfe.2010.05.00
- Heikkilä, J., Sirén, M., Ahtikoski, A., Hynynen, J., Sauvula, T., Lehtonen, M., 2009. Energy wood thinning as a part of the stand management of Scots pine and Norway spruce. *Silva Fennica* 43(1), 129-146.
- Hiltunen, V., Kurttila, M., Leskinen, P., Pasanen, K., Pykäläinen, J., 2009. Mesta: an internet-based decision-support application for participatory strategic-level natural resources planning. *Forest Policy and Economics* 11, 1-9.
- Horne, P., 2006. Forest owners' acceptance of incentive based policy instruments in forest biodiversity conservation – a choice experiment based approach. *Silva Fennica* 40(1), 169-178.
- Horne, P., Koskela, T., Ovaskainen, V., Karppinen, H., Horne, T., 2009. Forest owners' attitudes towards biodiversity conservation and policy instruments used in private forests. In: Horne, P., Koskela, T., Ovaskainen, V. & Horne, T. (eds.). *Safeguarding forest biodiversity in Finland: Citizens' and non-industrial private forest owners' views*. Metlan työraportteja/ Working Papers of the Finnish Forest Research Institute 119, 33-51.
- Huuskonen, S., 2008. The development of young Scots pine stands – precommercial and first commercial thinning. *Dissertationes Forestales* 62. [in Finnish]
- Huuskonen, S., Ahtikoski, A., 2005. Ensiharvennuksen ajoituksen ja voimakkuuden vaikutus kuivahkon kankaan männiköiden tuotokseen ja tuottoon. *Metsätieteen aikakauskirja* 2, 99–115. [in Finnish]
- Hynynen, J., Ojansuu, R., Hökkä, H., Siipilehto, J., Salminen, H., Haapala, P., 2002. Models for predicting stand development in MELA System. *Metsäntutkimuslaitoksen tiedonantoja - The Finnish Forest Research Institute, Research Papers* 835. 116 p.
- Hynynen, J., Ahtikoski, A., Siitonen, J., Sievänen, R., Liski, J., 2005. Applying the MOTTI simulator to analyse the effects of alternative management schedules on timber and non-timber production. *Forest Ecology and Management* 207, 5-18.
- Hyytiäinen, K., Tahvonen, O., 2001. The effects of legal limits and recommendations on timber production: the case of Finland. *Forest Science* 47(4), 443-454
- Jonsson, M., Ranius, T., Ekvall, H., Bostedt, G., Dahlberg, A., Ehnström, B., Norden, B., Stokland, J.N., 2006. Cost-effectiveness of silvicultural measures to increase substrate availability for red-listed wood-living organisms in Norway spruce forests. *Biological Conservation* 127, 443-462.
- Juutinen, A., Mäntymaa, E., Mönkkönen, M., Salmi, J. 2004., A cost-efficient approach to selecting syands for conserving species: a case study from Northern Fennoscandia. *Forest Science* 50(4), 527-539.
- Juutinen, A., Mäntymaa, E., Mönkkönen, M., Svento, R., 2008. Voluntary agreements in protecting privately owned forests in Finland – to buy or to lease ? *Forest policy and economics* 10, 230-239.
- Juutinen, A., Ollikainen, M., 2010. Conservation contracts for forest biodiversity: theory and experience from Finland. *Forest Science* 56(2), 201-211.
- Kangas, A., Haapakoski, R., Tyrväinen, L., 2008. Integrating place-specific social values into forest planning – case of UPM-Kymmene forests in Hyrynsalmi, Finland. *Silva Fennica* 42(5), 773-790.
- Karjalainen, E., Komulainen, M., 1999. The visual effect of felling on small- and medium-scale landscapes in north-eastern Finland. *Journal of environmental management* 55,167-181.
- Karppinen, H., 1998. Values and objectives of non-industrial private forest owners in Finland. *Silva Fennica* 32(1), 43-59.

- Kurttila, M., Pykäläinen, J., Leskinen, P., 2006. Defining the forest landowner's utility-loss compensative subsidy level for a biodiversity object. *European Journal of Forest Research* 125, 67-78.
- Kuuluvainen, J., Karppinen, H., Ovaskainen, V., 1996. Landowner objectives and nonindustrial private timber supply. *Forest Science* 42(3), 300-309.
- Li, C., Wang, C-P., Liu, S-T., Weng, Li-Hsin., 2010. Forest value orientations and importance of forest recreation services. *Journal of environmental management* 91, 2342-2348.
- Lichtenberg, E., Tra, C., Hardie, I., 2007 Land use regulation and the provision of open space in suburban residential subdivisions. *Journal of Environmental Economics and Management*, 54(2), 199-213.
- Matala, J., Kärkkäinen, L., Härkönen, K., Kellomäki, S., Nuutinen, T., 2009. Carbon sequestration in the growing stock of trees in Finland under different cutting and climate scenarios. *European Journal of Forest Research* 128(5), 493-504.
- Mäkinen, H., Hynynen, J., Isomäki, A., 2005. Intensive management of Scots pine stands in southern Finland: First empirical results and simulated further development. *Forest Ecology and Management* 215, 37-50.
- Mäntymaa, E., Juutinen, A., Mönkkönen, M., Svento, R., 2009. Participation and Compensation Claims in Voluntary Forest Conservation: A Case of Privately Owned Forests in Finland. *Forest Policy and Economics*, 11, 498-507.
- Matala, J., Hynynen, J., Miina, J., Ojansuu, R., Peltola, H., Sievänen, R., et al., 2003. Comparison of a physiological model and a statistical model for prediction of growth and yield in boreal forests. *Ecological Modelling* 161, 95-116.
- Miina, J., Pukkala, T., Hotanen, J-P., Salo, K., 2010. Optimizing the joint production of timber and bilberries. *Forest Ecology and Management* 259, 2065-2071.
- Nalle, D.J., Montgomery, C. A., Arthur, J.L., Polasky, S., Schumaker, N.H., 2004. Modeling joint production of wildlife and timber. *Journal of Environmental Economics and Management* 48, 997-1017.
- Nielsen, A.B., Olsen, S.B., Lundhede, T., 2007. An economic valuation of the recreational benefits associated with nature-based forest management practices. *Landscape and Urban Planning* 80, 63-71.
- Olschewski, R., Benitez, P.C., 2010. Optimizing joint production of timber and carbon sequestration of afforestation projects. *Journal of Forest Economics* 16, 1-10.
- Ovaskainen, V., Hänninen, H., Mikkola, J., Lehtonen, E., 2006. Cost-sharing and private timber stand improvements: A two-step estimation approach. *Forest Science* 52(1), 44-54.
- Pohjola, J., Valsta, L., 2007. Carbon credits and management of Scots pine and Norway spruce stands in Finland. *Forest Policy and economics* 9, 789-798.
- Ranius, T., Ekvall, H., Jonsson, M., Bostedt, G., 2005. Cost-efficiency of measures to increase the amount of coarse woody debris in managed Norway spruce forests. *Forest Ecology and Management* 206, 119-133.
- Salminen, H., Lehtonen, M., Hynynen, J., 2005. Reusing legacy FORTRAN in the MOTTI growth and yield simulator. *Computers and Electronics in Agriculture* 49(1), 103-113.
- Siikamäki, J., Layton, F., 2007. Potential cost-effectiveness of incentive payment programs for the protection of non-industrial private forests. *Land economics* 83, 539-560.
- Siitonen, J., Martikainen, P., Punttila, P., Rauh, J., 2000. Coarse woody debris and stand characteristics in mature managed and old-growth boreal mesic forests in southern Finland. *Forest Ecology and Management* 128, 211-225.

Silvennoinen, H., Alho, J., Kolehmainen, O., Pukkala, T., 2001. Prediction models of landscape preferences at the forest stand level. *Landscape and Urban Planning* 56, 11-20.

Simonsen, R., Rosvall, O., Gong, P., Wibe S., 2010. Profitability of measures to increase forest growth. *Forest Policy and Economics* 12, 473-428.

Statistics Finland 2010. The Greenhouse Gas Inventory for the year 2008 reviewed. Information available at: [http://www.stat.fi/til/khki/2008/01/khki\\_2008\\_01\\_2010-11-19\\_tie\\_001\\_en.html](http://www.stat.fi/til/khki/2008/01/khki_2008_01_2010-11-19_tie_001_en.html)

Store, R., 2009. Sustainable locating of different forest uses. *Land use policy* 26, 610-618.

Temisevä, M., Tyrväinen, L., Ovaskainen, V., 2008. Maisema- ja virkistysarvokauppa: Eri maiden kokemuksia ja lähtökohtia suomalaisen käytännön kehittämiseksi. Metla's working papers 81. 54 p.

Tönnes, S., Karjalainen, E., Löfström, I., Neuvonen, M., 2004. Scenic impacts of retention trees in clear-cutting areas. *Scandinavian journal of forest research* 19, 348-357.

Tyrväinen, L., Silvennoinen, H., Kolehmainen, O., 2003. Ecological and aesthetic values in urban forest management. *Urban For. Urban Green* 1, 135-149.

Zhou, W., 2007. Economic effects of policy-relevant issues on timber and reindeer productions – the cost of increasing reindeer production in northern Sweden. *Forest policy and economics* Vol 9(6), 611-619.

## 5.7 SPAIN

Blasco, E., González-Olabarria, J.R., Rodríguez-Veiga, P., Pukkala, T., Kolehmainen, O. and Palahí, M., 2009. Predicting scenic beauty of forest stands in Catalonia (North-east Spain). *Journal of Forestry Research* 20, 73-78.

BOGC, 2007. Ordre MAH/279/2007, bases reguladores de les subvencions destinades a compatibilitzar les activitats apícoles amb la conservació de l'abellerol al territori de Catalunya i s'obre la convocatòria per a l'any 2007.

Campos, P., Ovando, P., Montero, G., 2008. Does private income support sustainable agroforestry in Spanish dehesa? *Land Use Policy* 25, 510-522.

Cervera, T., Farriol, R., Muñoz, A., Rabascall, X., 2004. Manual de redacció de plans tècnics de gestió i millora forestal (PTGMF) i plans simples de gestió forestal (PSGF). Instruccions de redacció i l'inventari Forestal. Centre de la Propietat Forestal. Departament de Medi Ambient i Habitatge. Generalitat de Catalunya

Consorci Forestal de Catalunya (Ed), 2010. Taules de preus de la fusta. Llotja de contractació i mercat en origen de Vic i Girona (10/04/2010). *Catalunya forestal* 102.

Diaz-Balteiro, L., Romero, C. 2003. Forest management optimisation models when carbon captured is considered: a goal programming approach. *Forest Ecology and Management* 174, 447-457.

DIBA 2010. Full informatiu dels productes forestals a Catalunya. *Mercat de la fusta* 11.

Diputació de Girona. 2010. Bases específiques reguladores de les subvencions per a actuacions en matèria forestal.

Edwards, D., Jay, M., Jensen, F., Lucas, B., Marzano, M., Montagne, C., Peace, A., Weiss, G. 2009. Public Preferences for Silvicultural Attributes of European Forests. EFORWOOD Deliverable D2.3.3 .

Flores, P., Velásquez, P., Martínez de Anguita, R., Romero Calcerrada, C. J., Novillo y M., Ruiz. A., 2008. Los sistemas de pago por servicios ambientales entre la adicionalidad y la subsidiariedad: aplicación a la belleza escénica en el pantano de San Juan, Madrid, España. *Invest Agrar: Sist Recur For* 17(1), 39-53.



Forestal Catalana, 2010. Banc de preus

Goetz, R., Hritonenko, N., Xabadia, A., Yatsenko, Y. 2007. Optimal management of a size-distributed forest with respect to timber and carbon sequestration.

Mundet, R., 2009. El pi blanc. *Pinus halepensis*. Catalunya forestal 97, 26-28.

Palahí, M., Pukkala, T. Pascual L. Trasobares. A., 2004. Examining alternative landscape metrics in ecological forest planning: a case for capercaillie in Catalonia. *Invest Agrar: Sist Recur For* 13(3), 527-538.

Palahí, M., Pukkala, T., Bonet, J.A., Colinas, C., Fischer, C.R., Martínez de Aragón, J., 2009. Effect of the inclusion of mushroom values on the optimal management of even-aged pine stands of Catalonia. *Forest Science* 55(6), 503-511.

Pastor et al. 2006. Proposta de millora de gestió forestal basada en la optima extracció de fusta i l'òptim emmagatzematge de carboni en un bosc del Pont de Suert en regimen de tala selectiva. Master thesis, University of Girona.